SILICON CHIP

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FEATURE:

Car Electronics Projects to Build

Flexible Vehicle Voltage Monitor

Car/Truck Battery Zapper & Checker

MORE ZIGBEE:

PICAXE Goes Wireless with XBee

Dirt Cheap Antennas to increase range

Contents

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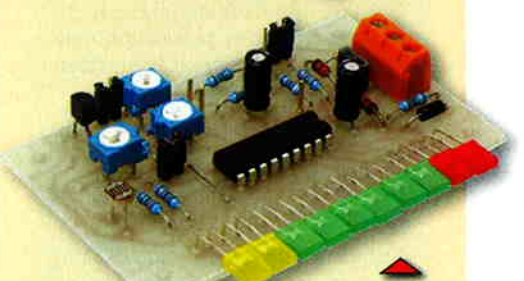
SILICON CHIP

Lead-Acid Battery Zapper & Condition Checker – Page 6.

Passive Direct Injection Box For Musicians – Page 62.



Vehicle Voltage Monitor – Page 78.

Boost Your XBee's Range Using Simple Antennas – Page 100.

FEATURES

24 Advances In Diesel Engine Management, Pt.2
A look at the electronic control systems – by Julian Edgar

30 Review: ELAB-080 Electronics Lab
Five general-purpose instruments in one low-cost package – by Peter Smith

PROJECTS TO BUILD

6 Lead-Acid Battery Zapper & Condition Checker
Improved design can check battery condition and has output sockets so that you can monitor the zapping pulses using a multimeter – by Jim Rowe

44 Universal High-Energy LED Lighting System, Pt.2
Second article has all the construction details. And we show you how to make a very effective Luxeon-powered spotlight for bicycles – by John Clarke

62 A Passive Direct Injection Box For Musicians
Don't let hum & noise spoil your performance. This DI box performs as well as a powered unit but doesn't need batteries – by John Clarke

72 Remote Mains Relay Box
Switch mains voltages safely with this easy-to-build unit – by Bill de Rose & Ross Tester

78 Vehicle Voltage Monitor
Want to monitor the battery voltage, the airflow meter signal or the oxygen sensor signal in your car? Here's the answer – by John Clarke

88 Picaxe Goes Wireless, Pt.2
Networking, logging data, plus light & temperature sensors – by Clive Seager

100 Boost Your XBee's Range Using Simple Antennas
Simple "roll your own" antennas for the XBee – by Stan Swan

SPECIAL COLUMNS

32 Circuit Notebook
(1) Automatic Exhaust Fan; (2) Rotary Encoder For PIC Projects; (3) Tank To Cistern Pump; (4) Picaxe-Powered Pocket Timer; (5) LED Torch Bulbs

40 Serviceman's Log
The one-day technician – by the TV Serviceman

68 Salvage It!
Improving the sound of salvaged loudspeaker systems – by Julian Edgar

94 Vintage Radio
The rare Edison R6 console receiver – by Rodney Champness

DEPARTMENTS

2 Publisher's Letter
4 Mailbag
61 Order Form
92 Product Showcase
102 Book Reviews
106 Ask Silicon Chip
109 Notes & Errata
110 Market Centre
112 Ad Index

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Publisher's Letter

iPOD hearing risk is nothing new

Recent reports about a legal suit in the state of California concerning the risk of hearing loss should not be regarded as anything really new. Allegedly, the iPOD can produce sound levels up to 115dB and if you are exposed to those levels for anything but a short time, you will certainly experience temporary hearing loss. If you do it repeatedly, you will go deaf.

Partly, the American legal suit is based on the fact that Apple has limited the output of iPODs sold in France to 100dB – still very loud but not as dangerous as 115dB. My response to this that all iPODs, MP3 players, Discmans, etc do come with a volume control. The iPOD's volume control is particularly intriguing but it works very well – you can turn the level up and down at will. Turn it up really high and yes, your hearing could be damaged. Do iPOD users care? Probably not.

Should they come with a hearing warning? No. Warnings don't work for cigarettes or alcohol so why would they work for iPODs.

Are you worried about your son's or daughter's hearing? If you can hear the music while they are wearing the earphones, it is probably quite loud, so yes, be concerned. I wish you good luck in trying to change their behaviour.

There is nothing new here. People have been abusing their hearing ever since personal music players have been around – for the last 25 years at least. Probably a majority of the population have inflicted significant hearing loss on themselves by the time they are 40. And because hearing loss is so insidious, they probably don't even know it. A huge number of people these days listen to their car radios or TVs with the sound levels very high – a sure sign that they are at least partially deaf.

In fact, I find it ironic that people willingly and regularly subject themselves to sound levels that would cause a punitive action against their employers by Workcover, if it happened while they were working.

Of more concern to me is the number of people who now wear (use?) iPODs while walking or jogging along the road. More usually than not, they jog while facing away from the traffic so they are completely oblivious to any hazard from passing traffic. In effect, they are lacking road sense as well as any concern for their own hearing. It seems to me that any pedestrian killed or injured while using an iPOD or other player must be regarded as having contributed to their own misfortune.

If you are a driver and you see someone jogging along the road, assume they are wearing an iPOD and be especially wary – they probably don't know you are right behind them!

Leo Simpson

Innovative • Unique • Interesting • Hard to find products

Pentium 4 with ISA Now supports LGA 775 CPUs!

This industrial motherboard is based on the Intel i915G chipset. It supports LGA 775 Pentium & Celeron processors.
Cat 17096-7 $699

Bluetooth Headset - Pendant Style

HOT PRICE

Cat 11916-7 $89

PCMCIA to Serial

Add two serial ports to your notebook.
Cat 2726-7 $269

What's New?

Temperature Logger

The Temperature Logger comes in two pieces, one being the reader and software and the other is the Sensor Tags. You can use multiple tags with the one reader, the reader and software can be installed on multiple machines.
The tags themselves have a similar face size to a credit card. They can log temperatures from -40 to +85 and store up to 8000 readings. The logging interval can be changed from 1min to several hours. Once the data is loaded into the software it can be saved and graphed etc or even exported to Excel or Word.
Cat 18211-7 Reader + Software $175
Cat 18210-7 Tags $69

Remote Power Switch

The Remote Power Switch (RPS) is an IP based, Web Controlled, AC power switch. Anyone with a web browser can access it to perform power On, Off or Reboot (timed power shutdown). The RPS is password protected for security. The unique Auto-Ping feature allows your RPS to monitor any IP device on the network and take automatic action whenever the device is down. The unit can be configure to ping a local device and automatically reboot if there is no response or it can be used to ping a remote host to monitor a communications channel and reboot the local modem if there is no response from the remote end etc.
Cat 8558-7 $499

Cordless Bluetooth Barcode Scanner

HOT PRICE

This cordless CCD scanner uses Bluetooth technology for reliable & accurate performance. Comes with Bluetooth dongle. Requires AA batteries (not included)
Cat 1008178-7 $599

FireWire 800 Card

This PCI card supports both FireWire A and the new B with speeds up to 800Mbps.
Cat 2997-7 $99

RFID Controller

Suitable for RFID security applications. RFID readers, electronic door locks, alarms, can all be attached to this unit.
Cat 1008079-7 $179

PCMCIA Dual Slot for PC

This Dual Slot PCMCIA adapter for PC allows a PCMCIA device to be used in a PC. The two built-in PCMCIA sockets in the 3.5" front Drive Unit connect to the PCI Interface Card.
Cat 6482-7 $199

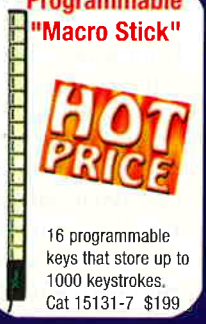
USB to 5.1 Sound

Perfect for use on a PC or Notebook. Has a 3.5mm and SPDIF connection.
Cat 23025-7 $59

Keypad with LCD

An 18 key keypad with LCD display and a serial connection to the PC.
Cat 1008168-7 $79

Programmable "Macro Stick"



HOT PRICE

16 programmable keys that store up to 1000 keystrokes.
Cat 15131-7 $199

Cardbus Gigabit Adapter

Upgrade your laptop LAN connection with this easy to install 10/100/1000 card.
Cat 11465-7 $65

FireWire External Case

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Suits a 2.5" laptop style HD.
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Simply take the memory card out of your camera and place it in the built-in memory card reader and setup a slideshow of your favourite pictures.
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Cat 4716-7 10.4in $829

Barcode Scanner

HOT PRICE

A great value robust scanner, perfect for retail and warehouse applications.
Cat 8698-7 $169

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Broadband Video Phone

Connect a standard telephone and TV to the VideoPhone, plug it into your Internet connection and you are ready to conduct real-time videoconferencing!
Cat 10181-7 $449

High Definition Video Switch Box

3 in, 1 out. Component Video with Stereo and Optical Audio.
Cat 23032-7 $99

12v Mini PC

This mini barebones PC is based on the VIA Eden 800Mhz processor and motherboard. It can operate on 12v or 240v making it ideal for use in boats or cars.
Cat 1167-7 $750

Compact Flash to IDE Adapter

Fits in a 3.5" bay and makes any CF card appear as an IDE device.
Cat 6741-7 $99

POS Customer Display

Features two lines of 20 characters that are 11.25mm high. Serial Connection.
Cat 8728-7 $359

USB 2.0 TV Box

Watch TV and Listen to FM radio on your PC or Laptop. Also supports capture from an RCA or S-Video input.
Cat 3527-7 $169

Dual ADSL Router

HOT PRICE

Enhance reliability and double your ADSL capacity by using two different ISP's.
Cat 10145-7 $199

16 Way KVM Switch

This rack-mountable switch allows one console to control up to 16 PC's.
Cat 11657-7 $799

USB VGA Adapter

Plugs into a USB 2.0 port and allows the user to extend their desktop over two screens (or three screens if already using a dual head video card).
Cat 15156-7 $179

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MAILBAG

Nuclear power stations do vent gases

In your reply to Rory Shannon's letter on nuclear power (Mailbag, February 2006), you stated that "nuclear power stations do not routinely vent radioactive gases".

This is not correct. The dominant design in the US, Babcock and Wilcox pressurised boiling water reactors (PWR), such as Three Mile Island, do exactly that. Short-lived daughters are formed in the primary loop and routinely vented in normal operation, for which they are licensed.

This has all been very well documented, not least by the US Nuclear Regulatory Commission in their 'WASH' incident reports. "Sniffing" the composition of reactor emissions is a stock tool of spying (eg, the US and North Korea).

Nuclear power stations do not operate in isolation but as part of a system; mining, fuel fabrication, operation, fuel waste treatment and reprocessing, intractable waste disposal and decommissioning.

Diversion of material for weapons, either nuclear or terrorist dirty bombs, is a real and very obvious concern (eg, Iran, North Korea, India, Pakistan, Israel and China). At least coal-fired power stations don't produce a highly toxic explosive as waste.

No power system, nuclear, hydro, geothermal, solar, wind, tidal, even fusion, can meet an endless and ever-growing demand.

The real question is how we maintain a genuine quality of life with far less energy use. The current winners, Big Energy Money, represented by the AP6 have no interest in fostering debate on this vital question.

Coupling our future well-being to ever growing energy use is junkie logic.

Roly Roper,
Ivanhoe, Vic.

Telephone ring cadence correction

In current March 2006 issue there is an article by Jim Rowe on a telephone/fax indicator circuit. He states that the cadence of ring current in Australia is 200 millisecond pulses of ring. In fact they are twice this and the cadence is 0.4 on, 0.2 off, 0.4 on, then two seconds off then repeat.

It is a small point but worth correcting.

Alec Slamin,
via email.

Salvage possibilities for washing machines

As a ruthless ratter/hoarder/tinkerer, I very much enjoy the "Salvage It!" article each month – so much so that I now look back a bit forlornly at those old washing machines that got away.

Would there be room for a stripper's list – the stuff that is worth extracting from some different kinds of ancient, wheezy or just busted appliances before chucking the stripped corpse?

And how about a "Salvage It!" online forum on what we have got and what we are after? Transport and handling can be a cost in all this, I know, but it seems a pity to limit your scrounging to just one pair of eyes and one "junk" box. Some of the online forums get a lot of use and could alert other dedicated salvagers to potential treasure troves.

Peter Brownlee,
Katoomba, NSW.

Comment: we've probably covered this topic in the past. However, if you are ratting washing machines, dishwashers or clothes dryers, you should certainly look at saving motors, motor/pumps, water solenoids or anything controlled by solenoids, water level and temperature sensors, timers and microswitches. You might also want to save drive belts and parts of the wiring harness with quick-connects. Of course, if you go overboard you will eventually find yourself with too much stuff that you can never use.

The pumps in washing machines and dishwashers could be useful in water reticulation, fish ponds, hydroponics and so on. Mind you, most of these items are not rated for continuous use and may not have a long life in these applications. If they are free though, that probably does not matter.

One other point should be considered. All motors used in appliances such as washing machines and dishwashers are usually of open-frame construction and have exposed windings and connections. Hence, if they are recycled, they should be housed in an earthed metal enclosure so that there is no possibility of accidental contact with them.

Too much bass could have been more

I was very impressed by Phil Prosser's letter (Mailbag, April 2006) showing his couch subwoofer. Like Mr Prosser, I am a devotee of the philosophy "you can never have too much bass".

My question to Mr Prosser is this: what's wrong with the back side of the couch? You could have fitted another four of the CS2345 subbys and looking at the picture of the couch, you could probably have fitted one at each end as well! Even more fun! Even more bass!

Gary Johnston,
Managing Director,
Jaycar Electronics.

Comment: Jaycar might sell a few more subwoofers as well, eh?

Question on PIC-based PLL

I have a possibly naive question about phase locked loops with which readers might be able to help. Is it easy or difficult to write a program for a PIC that will implement a phase locked loop that will recover the zero crossing from a 50Hz or 60Hz input that is badly mangled near the zero crossing but a clean sinewave elsewhere?

I've done quite a lot of the obvious

C-Tick sticker is no guarantee

The Mailbag pages for March 2006 featured a letter from Mike Abrams who was attempting to allay the fears of Graham Lill in relation to PC board track spacing in a compact fluoro. He suggests that we should purchase only products tested to Australian Standards and the C-Tick (EMC compliance) sticker is a good indication that the product complies.

I cannot comment on the fluoros he was referring to and their track spacing but would like to make the following comments:

I dismantled a failed dimmer many years ago from an Australian manufacturer/supplier and it was an approved type. Its track spacing did not seem to meet the standards for track spacing for 240VAC as required by a Telstra guideline.

I have recently returned a non-Australian made 2HP electric motor supplied as part of wood-working machinery and its grommetting of the 240VAC wires entering the case would have not met the standards of "the Irresponsible Cowboys Corporation" let alone any local standards.

I have a standard lamp of recent years made in Asia and approved for sale in Australia. It has figure-8 wiring which is cracking, exposing copper at the entry to the metal base and the grommet would not withstand the attack of a lethargic cockroach.

I can say absolutely that C-Tick compliance is NO GUARANTEE of anything, except perhaps that funds will be transferred to testing organisations.

I went through the C-Tick compliance testing process when operating a quite small business making single and multi-zone fire warning systems for the fire protection industry. We did get certification. As a process, the testing was logical but in our case I had to supply much of the test gear (large PSUs, etc). From an ongoing perspective, it was logical nonsense and a technical farce. I could detail why but it would take several pages.

I am advised that the C-Tick stickers can be purchased in newsagents and stationers in Germany.

I have a manual (ie, non-electric) steak knife made overseas and it has a C-Tick sticker on its cardboard box!

A 2-way radio gear supplier in Melbourne told me that he had test equipment from overseas that generated lots of EMI radiation but it had C-Tick stickers.

Sorry Mike. The real world submits reasonable things for test and then builds lower cost rubbish for sale – I have had many examples of it.

Ranald Grant,
via email.

homework, checking the Microchip website, buying a book about phase locked loops, surfing the web, testing ideas using Excel, etc.

I've also tried some hardware approaches using a 4046 but this was disappointing. It is mostly a "digital" phase locked loop and preserves rather than removes errors near the zero crossing. I also discovered that when I use a long time-constant for the loop filter, I needed to adjust the centre frequency accurately.

The XOR phase detector worked moderately well but finds the peak and I need extra circuits, such as at least one flipflop, to find the zero crossing. The PFD phase detector is very sensitive to the noise associated with the mangled zero crossing.

Naively, I assumed that it should be easy to write a PLL program for a PIC and that I'd find several programs on the Microchip website. None! I now think that a phase locked loop program might be too difficult for the 16F PICs and only just within the capabilities of the larger 18F PICs. Even as I type this, I also think, "that can't be right".

I'd be grateful for help from anyone able to answer the question.

Keith Anderson,
PO Box 58,
Kingston, Tas. 7051.

Atmel's AVR, from JED in Australia

JED has designed a range of single board computers and modules as a way of using the AVR without SMT board design

The AVR570 module (above) is a way of using an ATmega128 CPU on a user base board without having to lay out the intricate, surface-mounted surrounds of the CPU, and then having to manufacture your board on an SMT robot line. Instead you simply layout a square for four 0.1" spaced socket strips and plug in our pre-tested module. The module has the crystal, resetter, AVR-ISP programming header (and an optional JTAG ICE pad), as well as programming signal switching. For a little extra, we load a DS1305 RTC, crystal and Li battery underneath, which uses SPI and port G.
See JED's www site for a datasheet.

AVR573 Single Board Computer

This board uses the AVR570 module and adds 20 An./Dig. inputs, 12 FET outputs, LCD/Kbd, 2xRS232, 1xRS485, 1-Wire, power reg. etc. See www.jedmicro.com.au/avr.htm

$330 PC-PROM Programmer

This programmer plugs into a PC printer port and reads, writes and edits any 28 or 32-pin PROM. Comes with plug-pack, cable and software.

Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

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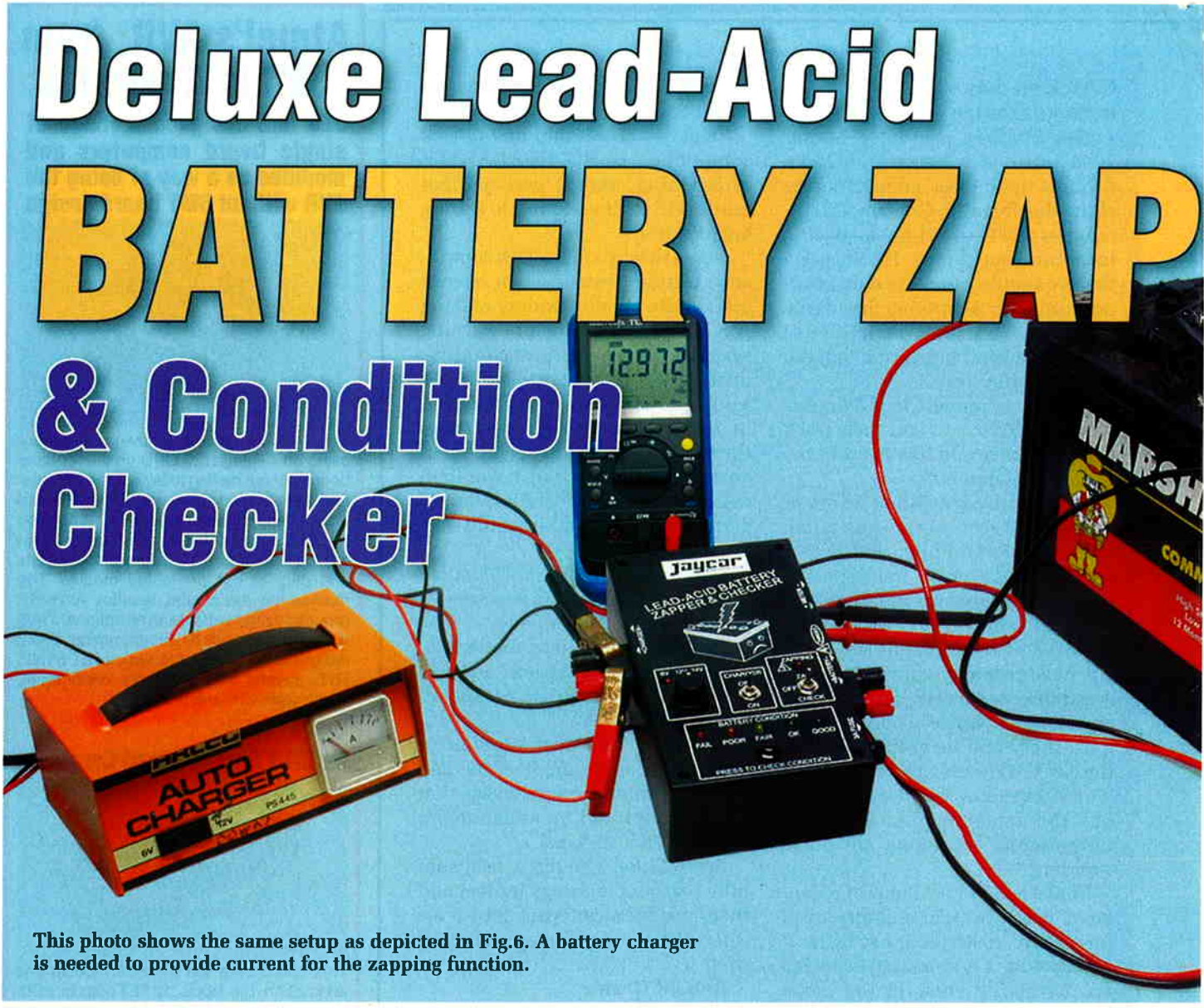
Deluxe Lead-Acid BATTERY ZAPPER & Condition Checker



This photo shows the same setup as depicted in Fig.6. A battery charger is needed to provide current for the zapping function.

Here's an improved design for a lead-acid battery desulphator or "zapper", combined with a battery condition checker. It has output jacks which let you monitor the zapping pulses with an external multimeter as zapping progresses, while an inbuilt isolating choke makes it easy to connect a charger to the battery during zapping.

THE SIMPLE LEAD-ACID battery zapper we described in the July 2005 issue of SILICON CHIP has been very popular with readers but a few shortcomings did become apparent as people started putting it to work desulphating their batteries.

For a start, when the zapper was connected to a battery with a high level of sulphation, the high voltage zapping pulses could rise in amplitude above the 100V rating of the switching MOSFET, causing it to suffer breakdown. A circuit modification to limit the maximum pulse voltage was published in the Notes & Errata section of the September 2005 issue (page 107).

We also showed how to connect a switch in series with one of the leads between the zapper and battery, to avoid dangerous sparking at the battery terminals when the connection was made or broken. A number of readers also enquired if they could fit an indicator to show when zapping was taking place, as it wasn't easy to

By JIM ROWE

PER

The circuit fits inside a standard UB2 plastic box and has output jacks so that you can monitor the "zapping" progress using a multimeter.

be sure of this unless you connected an oscilloscope across the battery terminals.

Another complication arose regarding the power MOSFET's over-voltage protection, because the MOSFET used in the July 2005 design became unavailable and the only replacements we could find were rated at just 60V. So the over-voltage limiting had to be changed again.

It also became clear that batteries needing desulphation must be connected to an external charger at the same time, because they couldn't provide the zapper with sufficient current. Although we had shown how this could be done, it did involve the use of an external "floating" inductor in series with one of the charger leads. Now we have incorporated the extra inductor inside the box.

Finally, the original design was only suitable for 12V batteries but many readers needed to desulphate 6V or 24V batteries as well.

Clearly, the best way of sorting out these drawbacks was to develop an improved Mk.2 zapper. At the same time, we decided to incorporate a battery condition checker, so that users would be able to check the condition of their batteries quickly and easily – either to see if zapping was necessary or after a zapping session, to see if there had been an improvement.

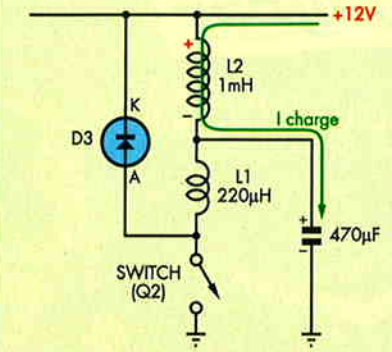
So that's the story behind this new unit. It's largely based on the July 2005 design but with a higher zap output and the ability to be used with 6V, 12V and 24V batteries. It also has the bonus of a built-in battery condition checker.

How it works

The zapper section of the new unit is very similar to the earlier unit. As we went into a fair amount of detail explaining how this worked in the July 2005 article, we won't repeat it in the same detail. It is illustrated in the three diagrams of Fig.1.

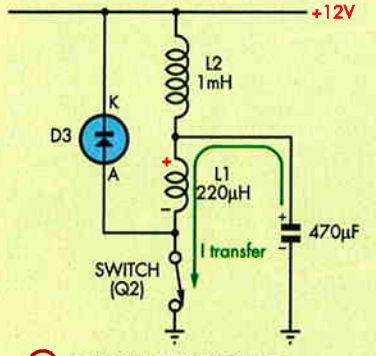
The zapping section of the circuit is shown in the upper part of Fig.2 (from the negative battery terminal upwards). In this case, it only operates when switch S1 is in the "Zap" position, connecting this part of the circuit to the battery and/or charger.

Current from the battery and/or



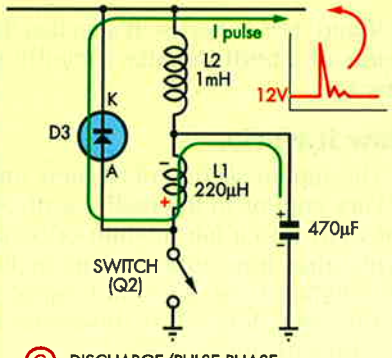
A CAPACITOR CHARGING PHASE

Fig.1(a): during the first phase of the circuit's operation, current flows from the battery (or charger) and charges a 100µF electrolytic capacitor via inductor L2.



B ENERGY TRANSFER PHASE

Fig.1(b): next, the switch is closed for 50µs, and current flows from the capacitor into L1. As a result, the energy stored in the capacitor is transferred to the inductor's magnetic field.



C DISCHARGE/PULSE PHASE

Fig.1(c): finally, the switch opens again, interrupting the inductor current and causing a high-voltage pulse across the inductor with the polarity shown. The green arrow shows the discharge current path.

charger flows through 1mH inductor L2 and charges the 470µF capacitor connected between the inductor's lower end and earth (battery negative).

At the same time, current flows through RF choke RFC1 and its 100Ω 5W series resistor, applying battery voltage to IC1, a 555 timer. Zener diode ZD1 is there to limit the supply voltage for IC1 to 16V when the unit is used with a 24V battery (and an accompanying charger).

IC1 is configured as an astable oscillator running at 1kHz, with an output consisting of narrow positive pulses about 100µs wide and with spaces of about 900µs between them (ie, 1:10 mark-space ratio).

The narrow pulses are used to turn on switching MOSFET Q2, with diode D2 and transistor Q1 used to ensure that Q2 is switched on and off as rapidly as possible. So Q2 is turned on for 100µs, off for 900µs and so on.

During the 900µs "off" periods, the 470µF capacitor is able to charge up to the battery voltage via inductor L2. When Q2 turns on, it connects the lower end of 220µH inductor L1 to ground, allowing some of the energy stored in the capacitor to be transferred into the magnetic field around L1. Then when Q2 turns off 100µs later, the magnetic field in L1 collapses again, delivering the stored energy back into the circuit in the form of a high voltage pulse (positive at the drain of Q2). Most of the energy in the high voltage pulses is fed to the battery via fast switching diode D3.

A number of small changes to the original zapper circuit have substantially increased the pulse energy.

Over-voltage protection

Diode D4 and zener diodes ZD2 and ZD3 form the over-voltage protection circuit for Q2, limiting the maximum pulse voltage at its drain to about 60V.

At the same time, diode D4 also functions as a half-wave rectifier and feeds a low-pass filter comprising a 47kΩ resistor and 100nF capacitor. This provides a DC voltage proportional to the maximum pulse amplitude to the "Meter" terminals. This allows monitoring of the pulse level with a standard multimeter.

As zapping progresses, the pulses will initially be quite high in amplitude. But if the zapping is working to successfully desulphate the battery, its internal impedance should drop and so the zapping pulses will be reduced in amplitude. So if you are monitoring the progress with a multimeter, the voltage should gradually reduce. If it doesn't, you know that the battery is effectively beyond redemption.

Fig.2 (right): IC1 and MOSFET Q2 provide the zapper function while the lower section of the circuit involving IC2-IC5 and MOSFETs Q3-Q6 provide a battery condition checker.

Visual indication

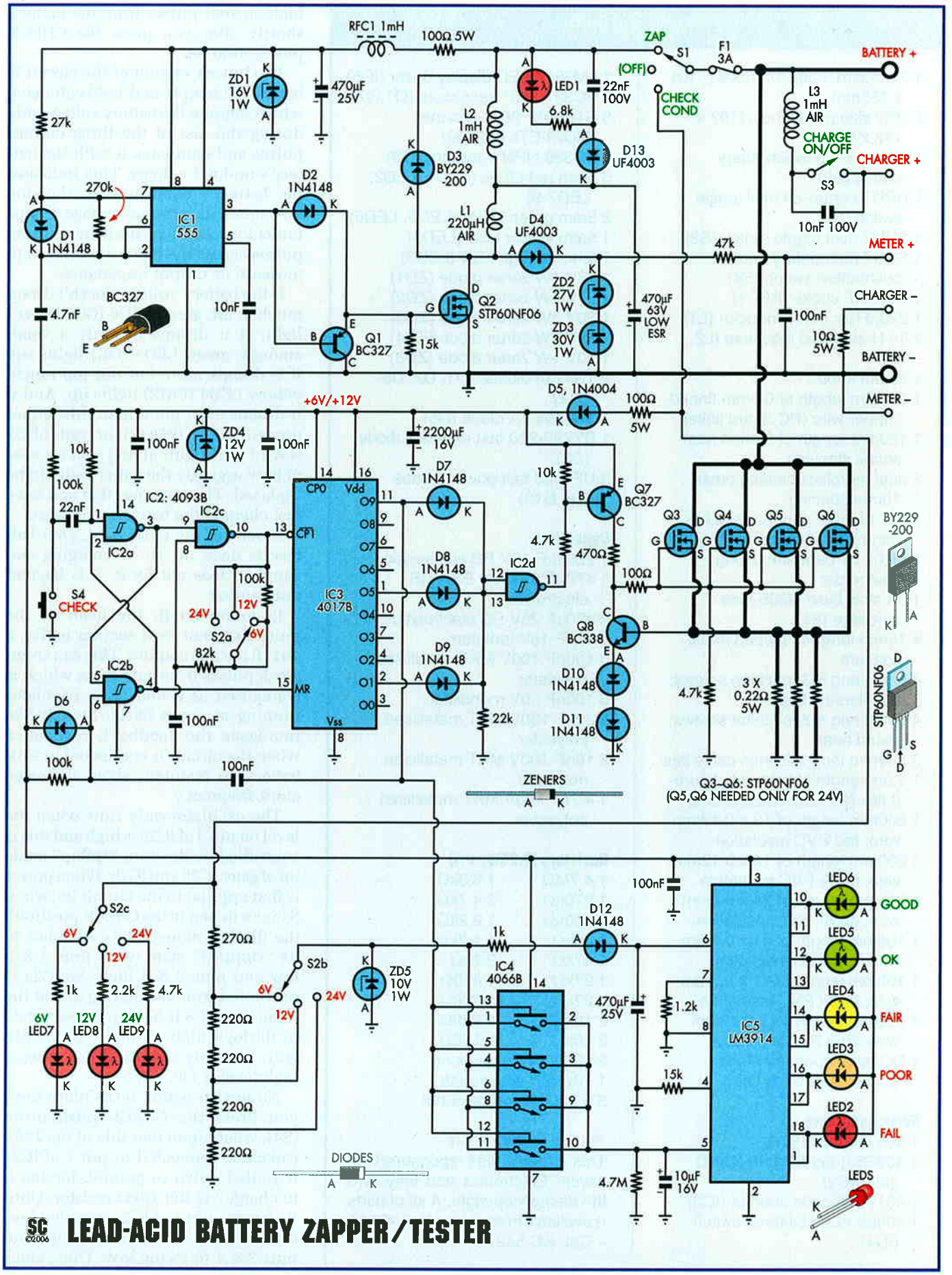
LED1 is provided to show when the zapper is generating pulses and also to give a rough idea of their amplitude. Because the pulses are quite narrow, diode D13 is used to charge the 22nF capacitor to their full voltage (less the battery voltage across the 470µF capacitor) and LED1 is able to draw a steady current from the capacitor via the 6.8kΩ resistor. Incidentally, the 22nF capacitor, in conjunction with diode D13, also functions as a snubber circuit to provide further damping of the high-voltage pulses produced at the drain of Q2.

The circuitry at upper right in Fig.2 is to allow safe connection of a standard battery charger to the battery at any time (ie, during zapping, condition checking or when neither is being carried out). Inductor L3 acts as a blocking choke for the zapping pulses, preventing the charger from possibly being damaged, while switch S3 with its 10nF spark suppressor allows the charger to be safely connected or disconnected, without producing any sparks.

The 10Ω 5W resistor in series with the negative charger lead is to limit the current that can be drawn from the charger, preventing damage when heavy current pulses are drawn from the battery during condition checking. It also reduces the likelihood of overcharging the battery if it is connected to the Zapper for a period of days.

Condition checking

The condition checking circuit is broken into two distinct parts: the centre section of Fig.2 incorporating IC2, IC3 and transistors Q3-Q8 and the lowest section involving IC4, IC5 and LEDs 2-9. Essentially, the centre section is a pulsed current load which draws a sequence of three very short



LEAD-ACID BATTERY ZAPPER/TESTER

Parts List

1 PC board, code 14105061, 101 x 185mm
1 UB2 size plastic box, (197 x 113 x 63mm)
1 3-pole 3/4-position rotary switch (S2)
1 DPDT centre-off mini toggle switch (S1)
1 SPDT mini toggle switch (S3)
1 SPST momentary contact pushbutton switch (S4)
1 1mH RF choke (RFC1)
1 220µH air cored inductor (L1)
2 1mH air cored inductors (L2, L3)
1 20mm knob
1 130mm length of 0.5mm tinned copper wire (PC board links)
1 150mm length of 2.5mm heat-shrink sleeving
2 dual red/black binding posts, 19mm spacing
1 pair of 4mm panel-mount banana jack sockets (red/black)
1 M205 LV panel-mounting fuseholder
1 3A slow blow M205 fuse cartridge (F1)
4 15mm long M3 tapped metal spacers
4 6mm long M3 machine screws, countersink head
4 6mm long M3 machine screws, round head
3 200mm long x 2.5mm cable ties
1 1.5m length of light duty figure-8 flex (for LED connections)
1 600mm length of 13 x 0.12mm wire, red PVC insulation
1 200mm length of 13 x 0.12mm wire, black PVC insulation
1 300mm length of 24 x 0.2mm wire, green PVC insulation
1 100mm length of 41 x 0.3mm wire, red PVC insulation
1 100mm length of 41 x 0.3mm wire, black PVC insulation
1 200mm length 13 x 0.12mm wire, blue PVC insulation
4 QC "eye" connector lugs, 5.3mm ID/9.5mm OD

Semiconductors

1 555 timer IC (IC1)
1 4093B quad Schmitt NAND gate (IC2)
1 4017B decade counter (IC3)
1 4066B quad bilateral switch (IC4)
1 LM3914 LED display driver (IC5)
2 BC327 PNP transistors (Q1,Q7)
5 STP60NF06 N-channel MOSFETs (Q2-Q6)
1 BC338 NPN transistor (Q8)
5 5mm red LEDs (LED1, LED2, LED7-9)
2 5mm green LEDs (LED5, LED6)
1 5mm yellow LED (LED4)
1 5mm orange LED (LED3)
1 16V 1W zener diode (ZD1)
1 27V 1W zener diode (ZD2)
1 30V 1W zener diode (ZD3)
1 12V 1W zener diode (ZD4)
1 10V 1W zener diode (ZD5)
9 1N4148 diodes (D1, D2, D6-D12)
1 1N4004 1A diode (D5)
1 BY229-200 fast recovery diode (D3)
2 UF4003 fast power diodes (D4,D13)

Capacitors

1 2200µF 16V RB electrolytic
1 470µF 63V low ESR RB electrolytic
2 470µF 25V RB electrolytic
1 10µF 16V tantalum
3 100nF 100V MKT metallised polyester
3 100nF 50V monolithic
2 22nF 100V MKT metallised polyester
2 10nF 100V MKT metallised polyester
1 4.7nF 100V MKT metallised polyester

Resistors (0.25W, 1%)

1 4.7MΩ	1 6.8kΩ
1 270kΩ	3 4.7kΩ
3 100kΩ	1 2.2kΩ
1 82kΩ	1 1.2kΩ
1 47kΩ	2 1kΩ
1 27kΩ	1 470Ω
1 22kΩ	1 270Ω
2 15kΩ	4 220Ω
2 10kΩ	1 100Ω

2 100Ω 5W wirewound
1 10Ω 5W wirewound
3 0.22Ω 5W wirewound

Where To Buy A Kit

This project was sponsored by Jaycar Electronics and they own the design copyright. A kit of parts is available from Jaycar for $A99.00 – Cat. KC-5427.

high-current pulses from the battery, shortly after you press the CHECK pushbutton S4.

The lowest section of the circuit is basically a sample-and-hold voltmeter, which samples the battery voltage only during the last of the three current pulses and compares it with the battery's no-load voltage. This indicates the battery's condition by showing how much its terminal voltage droops under load. In effect, the heavy current pulses across the battery enable us to measure its output impedance.

If the battery voltage doesn't droop much at all, green LED6 (GOOD) will light; if it droops by only a small amount, green LED5 (OK) lights up; if it droops more but not too much, yellow LED4 (FAIR) lights up. And if it droops even more than this, either orange LED3 (POOR) or red LED2 (FAIL) will light, giving you an idea of how urgently the battery should be replaced. This assumes that you have just charged the battery, of course.

If none of the LEDs light, your battery is dead or flat. If charging and zapping does not fix it, it is beyond redemption.

In more detail, the heart of the pulsed current load section is IC3, a 4017B decade counter. This can count clock pulses from gate IC2c, which is configured as a relaxation oscillator running at about 66Hz. Switch S2a increases the feedback resistance when the circuit is connected to a 6V battery, to maintain about the same clock frequency.

The oscillator only runs when the level on pin 9 of IC2c is high and this is controlled by the "run flipflop" made up of gates IC2a and IC2b. When power is first applied to the circuit (ie, when S1 is switched to the CHECK position), the flipflop immediately switches to its "stopped" state, with pins 3 & 5 low and pins 2 & 4 high. So IC2a is prevented from oscillating and at the same time, IC3 is held in its reset state by the logic high applied to its MR pin (15). The only output of IC3 at logic high level is O0, pin 3.

No further action takes place until you press the CHECK pushbutton (S4), whereupon one side of the 22nF capacitor connected to pin 1 of IC2a is pulled down to ground, forcing it to charge via the 10kΩ resistor. Until it charges, pin 1 of IC2a is pulled low, causing pins 3 & 5 to swing high and pins 2 & 4 to swing low. Thus, clock

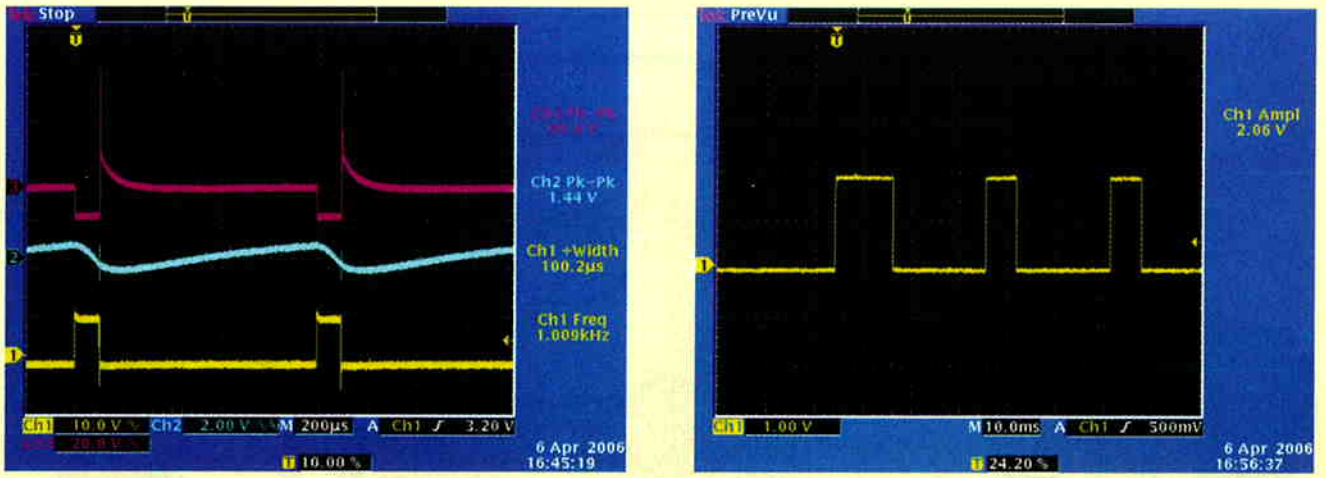


Fig.3: the scope waveforms at left were measured using a 12V battery with a series resistor of 2.7Ω to simulate a sulphated battery. The lowest trace (yellow) is the pulse train fed to the gate of Q2 while the top trace (purple) is the resultant high-voltage pulse developed at the drain of Q2. The blue trace shows the accompanying ripple voltage across the 470µF low-ESR capacitor. At right is the sequence of three current pulses used by the condition checker (measured across the paralleled 0.22Ω source resistors).

oscillator IC2c is enabled and at the same time the reset is removed from pin 15 of IC3.

The counter begins to count the pulses from IC2c and its outputs then switch high in sequence: first O1, then O2, O3 and so on up to O9. Each counter output switches high for around 15ms (milliseconds), so the complete sequence takes 9 x 15 = 135ms.

When output O9 finally drops low again at the end of the ninth clock period, the 100nF capacitor connected between this output and pin 6 of IC2b feeds a negative-going pulse back to IC2b, which resets the flipflop. This stops the clock and activity again ceases until S4 is pressed again.

So IC2a, IC2b, IC2c & IC3 form a digital sequencer which generates nine 15ms long pulses when pushbutton S4 is pressed.

Diodes D9, D8 & D7 are connected to the O1, O5 & O9 outputs of IC3. These diodes form an OR gate to feed the inputs of IC2d which are normally pulled down to 0V via a 22kΩ resistor. But when the sequencer runs and outputs O1, O5 & O9 switch high in turn (with 45ms gaps between them), the inputs of IC2d also switch high for 15ms each time.

As a result, IC2d's output (pin 11) switches low during these three 15ms periods, providing pulses of base current to turn on transistor Q7 for the same periods. And when Q7 conducts, it turns on MOSFETs Q3-Q6, to draw pulses of current from the battery.

Q3-Q6 are enhancement-mode MOSFETs connected in parallel, with their drains connected to battery positive and sources connected to battery negative via a parallel combination of three 0.22Ω resistors, giving an effective common source resistance of 0.073Ω. The MOSFET gates are pulled down to 0V via a 4.7kΩ resistor, so normally they are switched off and not conducting. But when the sequencer turns on Q7 for three 15ms pulses, this also turns on the MOSFETs and they draw pulses of current from the battery.

Pulse current limiting

The battery current pulses are limited by transistor Q8 and the two diodes connected in series with its emitter, in conjunction with the three 0.22Ω resistors in the source circuit of the MOSFETs. The base of Q8 is connected directly to the top of the source resistors, so that when the MOSFETs conduct, the resulting voltage across the source resistors provides forward bias for Q8.

Q8 doesn't conduct to any significant extent until the voltage drop across the MOSFET source resistors rises above 1.95V, where it matches the forward voltage drop of D11, D10 and Q8's own base-emitter junction. When that voltage level is reached, Q8 begins to conduct, draining away some of the MOSFET forward bias reaching their gates via the 470Ω and 100Ω resistors. As a result, the MOSFET current is automatically limited to a value which produces about 2V across the source resistors; ie, around 2V/0.073Ω, or 28A.

So when you press pushbutton S4, a sequence of three pulses of around 28A is drawn from the battery, each around 15ms in duration and 45ms apart.

Checking the droop

As explained earlier, the circuitry around IC4 and IC5 forms a sample-and-hold voltmeter. It compares the battery voltage during the last of the

Warning!

This circuit generates high voltage pulses which could easily damage the electronics in a vehicle. Do not connect it to a car battery installed in a vehicle.

Disclaimer!

Not all batteries can be rejuvenated by zapping. They may be too heavily sulphated or may have an open-circuit cell connection. Nor can the zapper restore a battery which is worn out; ie, one in which the active material on the plates has been severely degraded.

Depending on the battery, it is also possible that any rejuvenation effect may only be temporary.

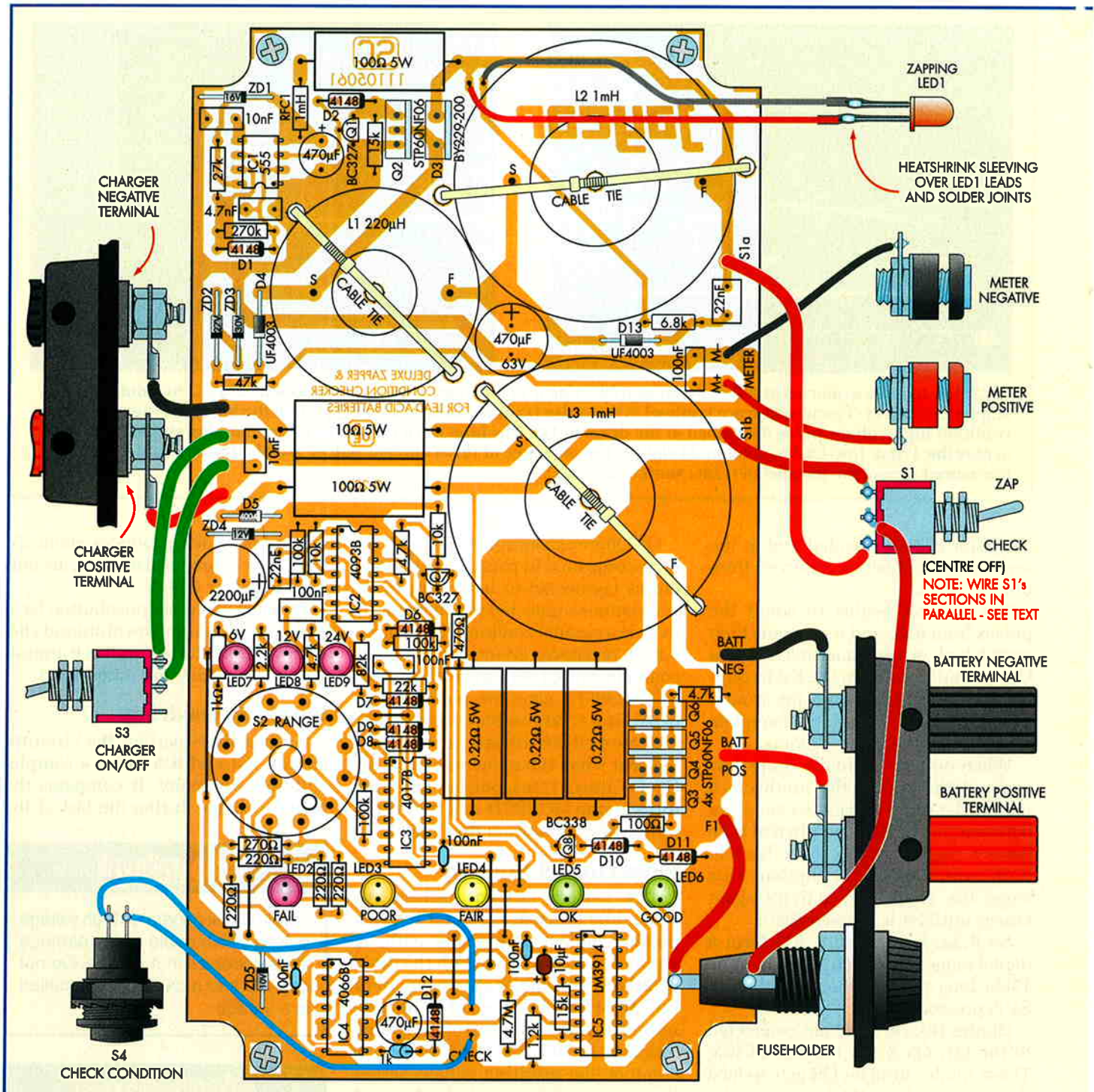


Fig.4: follow this parts layout diagram to assemble the PC board and complete the external wiring. Make sure that all polarised parts are installed with the correct orientation.

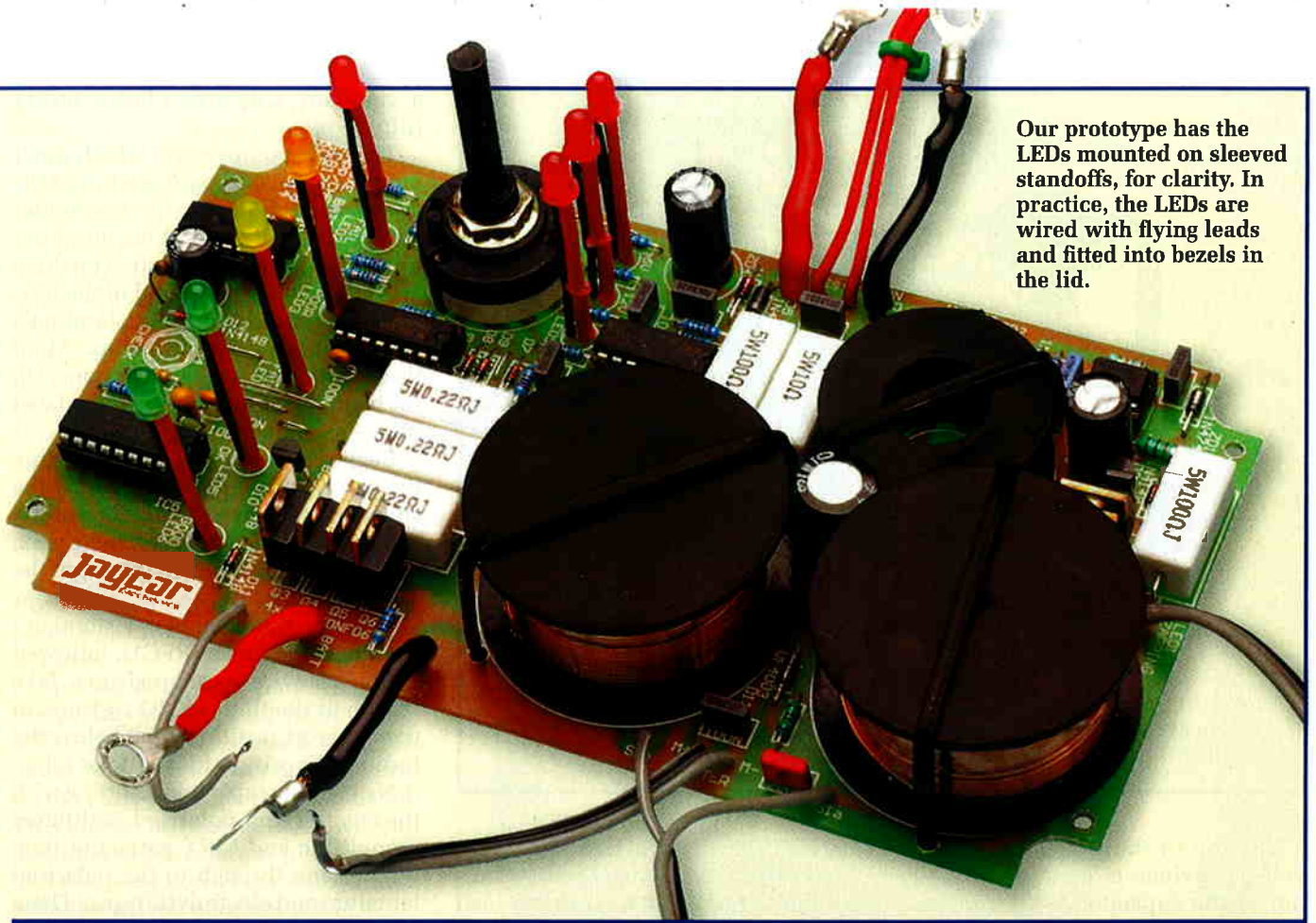
three 15ms pulses against the voltage when no current is being drawn, because this "droop" is a fairly good indicator of the battery's condition.

The heart of the voltmeter is IC5, an LM3914 LED driver IC. The LM3914 is basically a set of 10 voltage comparators, with the reference inputs of the comparators connected to taps on an internal voltage divider. The top of the divider connects to pin 6, while the bottom connects to pin 4.

The second input of all 10 comparators is fed with the input voltage from pin 5, via an internal buffer amplifier.

The outputs of the comparators are used to drive current sinks, one for each LED driver output pin. Only five LEDs are used, with each LED connected to an adjacent pair of outputs so they provide a resolution of only five voltage ratio levels.

Although the LM3914 has an internal voltage reference, it's not used here. The reference pin (pin 7) is simply connected to ground via a 1.2kΩ



Our prototype has the LEDs mounted on sleeved standoffs, for clarity. In practice, the LEDs are wired with flying leads and fitted into bezels in the lid.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	4.7MΩ	yellow violet green brown	yellow violet black yellow brown
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	82kΩ	grey red orange brown	grey red black red brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	2	15kΩ	brown green orange brown	brown green black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	3	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	270Ω	red violet brown brown	red violet black black brown
❑	4	220Ω	red red brown brown	red red black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

resistor, to set the LED current levels correctly.

So that we can use the circuit to compare the on-load battery voltage with its off-load value, we use the off-load battery voltage as the voltmeter's reference. Actually, we use a proportion of the battery voltage, as selected by switch S2b, because the LM3914's input voltage range must be limited for linear operation. So S2b selects a suitable proportion of the battery voltage, depending on whether a 6V, 12V or 24V battery is being tested. This voltage is fed through a 1kΩ resistor and diode D12 to charge the 470µF capacitor and this provides our 'no load" voltage reference for the LM3914.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100n
22nF	.022µF	223	22n
10nF	.01µF	103	10n
4.7nF	.0047µF	472	4n7

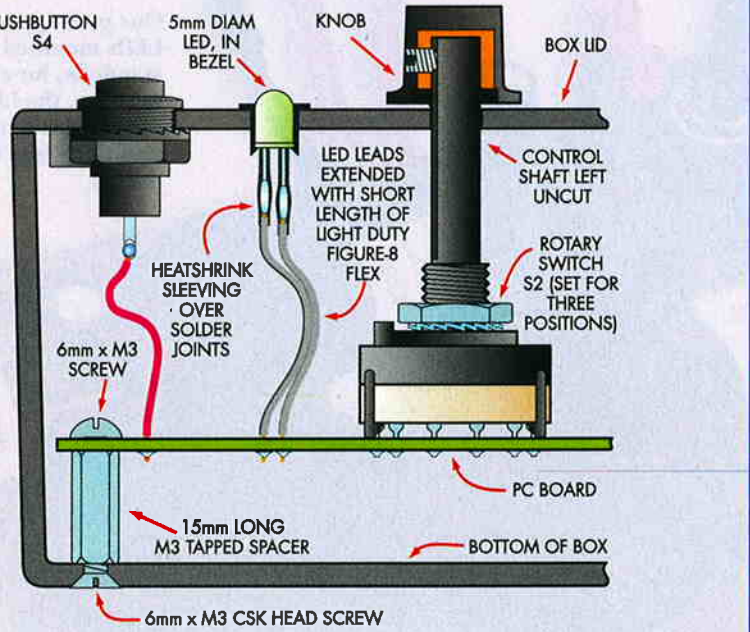

PUSHBUTTON S4
5mm DIAM LED, IN BEZEL
KNOB
BOX LID
LED LEADS EXTENDED WITH SHORT LENGTH OF LIGHT DUTY FIGURE-8 FLEX
CONTROL SHAFT LEFT UNCUT
ROTARY SWITCH S2 (SET FOR THREE POSITIONS)
HEATSHRINK SLEEVING OVER SOLDER JOINTS
6mm x M3 SCREW
PC BOARD
15mm LONG M3 TAPPED SPACER
BOTTOM OF BOX
6mm x M3 CSK HEAD SCREW

Fig.5: this cross-sectional diagram shows the mounting details for the LEDs and the rotary switch.

The top of the LM3914's internal voltage divider is connected to the top of the capacitor, while the bottom of the divider is connected to ground/battery negative via a 15kΩ resistor. This expands the range of the LM3914's comparator voltage divider to the upper 40% of the total reference voltage.

Voltage sampling

Sampling of the on-load voltage is performed by IC4, a 4066B quad bilateral switch with all four switches connected in parallel to minimise on-resistance. The control inputs of the switches are connected to the O9 output of IC3, so the switches are normally "off" and are only turned on during the third pulse of each load pulse sequence. When this occurs, the switches allow the 10µF capacitor connected to pin 5 of IC5 to charge up to the proportion of battery voltage selected via S2b – the same voltage proportion used to charge the 470µF capacitor but in this case it samples what happens to it when the battery is attempting to provide 30A pulses of current.

The LM3914 therefore compares the selected proportion of the battery's no-load voltage (pin 6) with the same proportion of its on-load voltage (pin 5). If the voltage droops very little, LED6 will light; if it droops a little more, LED5 will light and so on.

Note that if the on-load battery voltage drops below 60% of its no-load value, none of the LEDs will light – that's why a "no glow" indicates that the battery is either flat or completely dead.

Note too that regardless of which LED lights during the test to indicate battery condition, after a few seconds the glow will transfer down through the lower LEDs and then finally they'll all go dark again. That's because the sampled on-load voltage held by the 10µF capacitor is gradually leaked away by the parallel 4.7MΩ resistor, to ready the circuit for another test.

The 10V 1W zener diode (ZD5) connected to the wiper of switch S2b is there to protect the inputs of IC4 & IC5, in case the 6V battery position is selected while a 24V battery is connected. Without ZD5, both IC4 & IC5 could be destroyed by this mistake.

The third pole of switch S2 (S2c) is used to indicate which battery voltage has been selected, via LED7-LED9.

Construction

To make the new Battery Zapper & Checker reasonably easy to build, almost all of the components used are mounted directly on a PC board coded 14105061 and measuring 101 x 185mm. This has rounded cutouts in each corner so it will fit snugly inside a standard UB2-size plastic utility (Jiffy) box.

The only components which don't mount on the PC board are the LEDs, switches S1, S3 & S4, the fuseholder for fuse F1 and the various input terminals and banana sockets. The three switches mount on the lid of the box, while the fuseholder and terminals mount on the sides of the box. All of these off-board components connect to the board via short lengths of insulated wire – see Fig.4.

Begin the board assembly by fitting the seven wire links. **Don't forget the short link between diodes D7 and D9, just to the right of rotary switch S2, or the longer link just to the left of the same switch.**

Next, fit the smaller resistors and the small RF choke (RFC1), followed by the 5W wirewound resistors. Take care to fit the three 0.22Ω resistors in their correct positions just below the indicated position for inductor L3.

Next, fit the capacitors, starting with the smaller non-polarised multilayer monolithic and MKT parts and then progressing through to the polarised tantalum and electrolytic types. There are not many of these but take care to fit them with the correct orientation.

Now you can fit the semiconductors, starting with the various diodes and then the bipolar transistors (Q1, Q7 & Q8), the ICs (or sockets for them if you wish) and the power MOSFETs. The semiconductors are all polarised, so be sure to install them correctly.

When fitting MOSFETs Q3-Q6, leave about 5mm of their leads above the board (ie, the wider 4mm long sections plus a further 1mm). **This is necessary because they need to be bent over at about 45° later, so that their top tabs clear the contacts of switch S1 when everything is assembled. Although not shown in the photos, the two lower MOSFETs must be bent downwards towards D11, while the upper MOSFETs are bent upwards towards L3.**

Mounting the LEDs

The LEDs are all connected to the PC board using 150mm lengths of light-duty figure-8 flex and the LEDs themselves fitted into bezels on the front panel. Each LED is fitted with its connecting lead first. Do this by separating the two lead wires at one end for about 20mm and then removing about 6mm of insulation from each. Then slip a 15mm length of 2.5mm

heatshrink sleeving down over each wire, before soldering the two wires to the LED leads (which have been previously cut short, to about 12mm long).

When you solder the wires, make sure you solder the wire with the black stripe to the LED's cathode lead. After both joints are made, slide the heatshrink sleeves up and over the solder joints, so they are fully covered, and heat them with a hot-air gun or by rubbing them with the barrel of your soldering iron, so they shrink into place.

Once the leads have been fitted, the LEDs can all be attached to the PC board. Be sure to fit them in the correct positions and with the correct polarity.

Special note: our photograph of the prototype shows all LEDs except LED1 mounted on sleeved standoffs about 40mm high, just high enough to let the LEDs protrude through the lid. This has the advantage of showing an uncluttered board in our photographs and allowing more easy comparison with the wiring diagram of Fig.4.

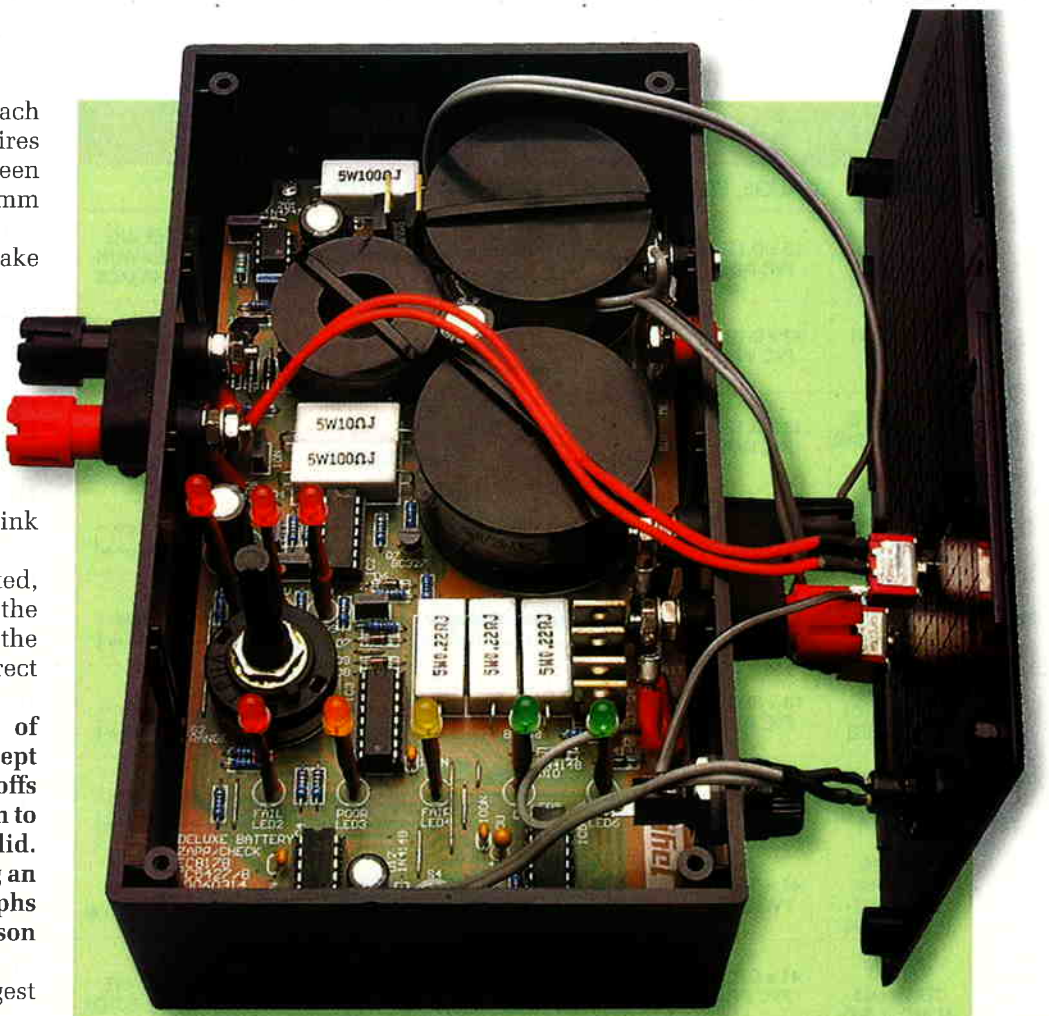
That done, it's time to fit the largest components to the board – ie, rotary switch S2 and the three air-cored inductors. There's no need to cut S2's control shaft before it's fitted to the board. Instead, it's left at full length so that it will later protrude far enough through the box lid to accept the control knob. However, you do need to make sure that the switch is set for only three positions.

This is done by first turning the control shaft as far as it will go in the anticlockwise direction and then unscrewing the mounting nut and removing this from the threaded ferrule, along with the star lockwasher. That done, use a small screwdriver to prise up the indexing pin washer from its position under the star lockwasher and then carefully replace it so that its indexing pin slips down into the rectangular hole between the numerals '3' and '4' which are moulded into the plastic. Make sure the washer is sitting down flat before replacing the lockwasher and mounting nut.

If you now try turning the control shaft by hand, it should have three only possible positions.

You can now fit the switch in position, making sure that all its connection pins pass through the board holes and that the bottom of the switch sits flush against the board. **Note that in this project, the switch orientation is NOT with the locating spigot pin at 12 o'clock but at the 5 o'clock position.** This is shown clearly on the overlay diagram (Fig.4).

When you are happy that the switch is orientated correctly and is sitting flat on the board, turn the board over and solder all of the pins to the pads underneath.



This is the view inside the completed prototype. Note that in the kit version, the LEDs are connected to flying leads and clipped into bezels mounted on the front panel.

Air-cored inductors

The air-cored inductors are also mounted directly on the PC board. It's important to dress each inductor's leads carefully so they're each straight and at close to 90° to the side cheeks of the inductor bobbin, to prevent strain as the inductor is lowered against the board.

Make sure also that you orientate each inductor so that its "start" lead (nearer the centre of the bobbin) passes through its matching "S" hole on the board. The "finish" lead (further out) goes through the hole marked "F".

When each inductor is sitting flat against the top of the board, you can solder its leads to the pads underneath and trim off any excess. That done, use a 200mm-long cable tie to hold the inductor in place, passing the tie down through one of the edge holes provided in the board and up through the other.

All that remains now is to plug the ICs into their sockets (taking care to fit them with the correct orientation) and then prepare and fit the various short lengths of wire for the off-board connections.

There are 14 of these connection wires to be prepared: two each for the charger and battery terminal connections; two for the meter jacks; two for the charger on/off switch (S3); two for the main function switch (S1); two for pushbutton switch S4; one for the end terminal of the fuseholder; and finally, one for the connection between the

Table 3: Off-Board Wiring Connection Details

WIRE USE	GAUGE, ETC	LENGTH & OTHER DETAILS
WIRES TO METER JACKS (1 RED, 1 BLK)	13 x 0.12mm PVC INSUL	40mm — SOLDER LUG SUPPLIED WITH BANANA JACK
WIRES TO S1 (2 x RED)	13 x 0.12mm PVC INSUL	120mm
WIRE TO END OF FUSEHOLDER (1 x RED)	13 x 0.12mm PVC INSUL	80mm
WIRE FROM FUSEHOLDER TO CENTRE LUGS OF S1	13 x 0.12mm PVC INSUL	80mm
WIRES TO S4 PUSHBUTTON (2 x BLUE)	13 x 0.12mm PVC INSUL	100mm
WIRES TO ZAPPING LED1 (1 RED, 1BLK)	13 x 0.12mm PVC INSUL	150mm
WIRES TO S3 CHARGER SW (2 x GRN)	24 x 0.2mm PVC INSUL	150mm
WIRES TO CHARGER TERMINALS (1 RED, 1 BLK)	41 x 0.30mm PVC INSUL	50mm — 'QC' EYE CONNECTOR
WIRES TO BATTERY TERMINALS (1 RED, 1 BLK)	41 x 0.30mm PVC INSUL	50mm — 'QC' EYE CONNECTOR

fuseholder side lug and the centre lugs of switch S1.

To make it easier to prepare all these wires, their details are shown in Table 1. Note that the wires for the meter terminals are of light-duty hookup wire and this also applies to the wires for S4, S1 and the fuseholder. On the other hand, the wires for charger switch S3 and especially the charger and battery terminals should be made from heavier wire, because they carry higher currents.

Warning!

Hydrogen gas (which is explosive) is generated by lead-acid batteries during charging. For this reason, be sure to always charge batteries in a well-ventilated area.

Never connect high-current loads directly to a battery's terminals. This can lead to arcing at the battery terminals and could even cause the battery to explode! Note too that the electrolyte inside lead-acid batteries is corrosive, so wearing safety glasses is always a good idea.

Note also that the wires for the meter jacks have matching large solder lugs fitted to their far ends, while the wires for the charger and battery terminals are fitted with suitable "QC eye" connector lugs (see parts list) for easy attachment to the rear of the terminals using the nuts provided.

Once all of these wires are prepared, you can pass the "board end" of each wire through its corresponding hole on the board and solder it to the pad underneath. Your board assembly should then be complete and ready to be fitted into the box, although you should first give it a thorough inspection, to make sure there are no dry solder joints, joints that have been forgotten altogether or accidental solder bridges between pads or tracks.

Final assembly

Before lowering the board assembly into the box, secure the four 15mm-long tapped spacers inside the bottom of the box using countersink-head M3 x 6mm machine screws. That done, lower the board onto the spacers and secure it in place using four round-head M3 x 6mm machine screws.

Next, fit the meter connection jack sockets, the charger and battery connection terminals and the fuseholder to the sides of the box. With both the meter jacks and the charger/battery terminals, you have to disassemble them first before you can fit them to the box and then reassemble them with a single nut inside. When you have tightened these nuts, slip the solder lugs or QC connectors over the ends of the threaded sleeves or shafts and then add a second nut to each connector to fasten them in place.

The fuseholder is pushed through its mounting hole and the washer and nut refitted. Don't use excessive force to tighten the nut though, as this may strip the plastic thread. Once the fuseholder is in place, you can solder the end of the wire from the PC board to its end connection lug.

Next, fit toggle switches S1 & S3 to the box lid. S3 is a single-pole switch which mounts in the central hole of the lid, while S1 is a double-pole centre-off switch which mounts in the righthand hole. After these, fit push-button switch S4 in the centre hole at the bottom of the lid.

You should now be ready to make the last off-board connections, so turn over the box lid and bring it close alongside the box itself. First of all, use the remaining loose length of prepared wire (80mm of 13 x 0.12mm, red PVC insulation) to connect the side lug of the fuseholder to the two centre terminal lugs of switch S1 **(note: the two sections of S1 are connected in parallel, to give greater current handling capacity).** That done, solder the free ends of the remaining red wires from the board ("S1a" and "S1b") to the lugs at each end of switch S1 – see (Fig.2). **The "S1a" wire goes to the two lower lugs of S1, while the "S1b" wire goes to the two upper lugs.**

Next, solder the leads to pushbutton switch S4. The switch wiring can then be completed by soldering the free ends of the two green wires coming from centre left of the PC board to the centre and uppermost lugs of S3 (the charger on/off switch).

Panel-mounting the LEDs

You can now fit the plastic bezels for the nine LEDs into their holes in the lid. When each bezel is in place, push its LED up from below until it clicks into place. Just make sure you fit each

LED into its correct position or you'll get some strange results later!

That done, you can lower the lid down onto the box, with the rotary switch spindle passing through its clearance hole. Fasten it with the self-tapping screws provided, fit the small plastic bungs over each screw recess and fit the control knob on the rotary switch spindle.

Using it

Now for the smoke test. First, make sure that the Zapper's switches are set as follows: S1 in its centre-Off position, S2 for the correct nominal battery voltage and S3 in its upper-Off position. That done, connect it as shown in Fig.6. The Zapper's battery terminals are connected directly to the battery using heavy-gauge cables. Just make sure you connect the positive terminal to battery positive and the negative terminal to battery negative, or very nasty things can happen.

If you are going to zap the battery, you'll also have to connect your charger to the Zapper's charger terminals: again, positive to positive and negative to negative. This is because a sulphated battery cannot deliver the 200mA or so of current required by the Zapper.

Once the charger is connected, switch S3 on the Zapper to "On" (assuming you've already connected the Zapper to the battery). Note that if you are using a multimeter to monitor the zapping pulses, it should be set for a DC voltage range of 20V or 50V.

To begin zapping the battery, switch S1 to its "Zap" position. The Zapping LED should immediately light, showing that the high-voltage zapping pulses are being applied to the battery. If you have a multimeter connected, it should be giving a reading of about 30V DC or thereabouts; this is not the actual peak-to-peak pulse voltage but an average value proportional to it.

As zapping progresses, this voltage reading should slowly drop, as the lead sulphate crystals in the battery are gradually dissolved. So let's say you've been zapping the battery for a day or two and also charging it at the same time. Now you want to check the battery's condition. This is done as follows:

First, turn the Zapper's Charger switch S3 to the Off position, so you'll be checking the battery by itself and not the charger as well. Then, after making sure S2 is set for the battery's nominal voltage (6V/12V/24V), move function switch S1 down to its lower Check position. One of the LEDs above the knob for S2 should light, confirming the battery voltage setting. The Good Condition LED (LED6) will also light briefly, then the OK LED, the Fair LED and so on, down to the Fail LED. This "ripple down" effect is caused by the time taken for the LM3914 reference voltage to stabilise after switch-on.

Once the Condition LEDs have all gone dark again, simply press the Check pushbutton (S4) briefly. Now one of the Condition LEDs should light again, to show the battery's actual condition – hopefully it will be the "Good" or "OK" LED, if the battery has responded to the zapping.

After a few seconds, the lit LED will fade out and the LED next down from it will light instead. Then the next LED to its left will light and so on, until all five LEDs are dark again.

When they are all dark it's a good idea to press S4 again for a second check, because a single check may give a reading that's lower than the battery's actual condition. So if you do press S4 again, you'll very likely get a higher reading than the first time if the battery really is in "Good" or "OK" condition.

If you only get a reading of "Fair", "Poor" or "Fail", even on the second check, your battery isn't in good shape and needs more zapping. And if further zapping doesn't give better readings, your battery is essentially dead and ready for replacement.

By the way, you can check the battery condition any time you wish. Because each check only draws three very short pulses of current from the battery, it draws a negligible amount of charge – about 1.35 coulombs or 0.000375Ah. Your charger can probably replace this in a couple of seconds.

You'll also notice that when you exit the battery checking function by switching S1 back to its centre-off position, the Condition LEDs again light briefly, this time from the lowest to the highest. This occurs as the LM3914's reference voltage decays and is nothing to worry about.

By the way, note that regardless of the battery charger you use, the charge current is limited by the circuit to less than 1A. We did this because we did not want the risk of severely overcharging a battery during a period of zapping over several days. So after zapping successfully, the battery may still need further charging. **SC**

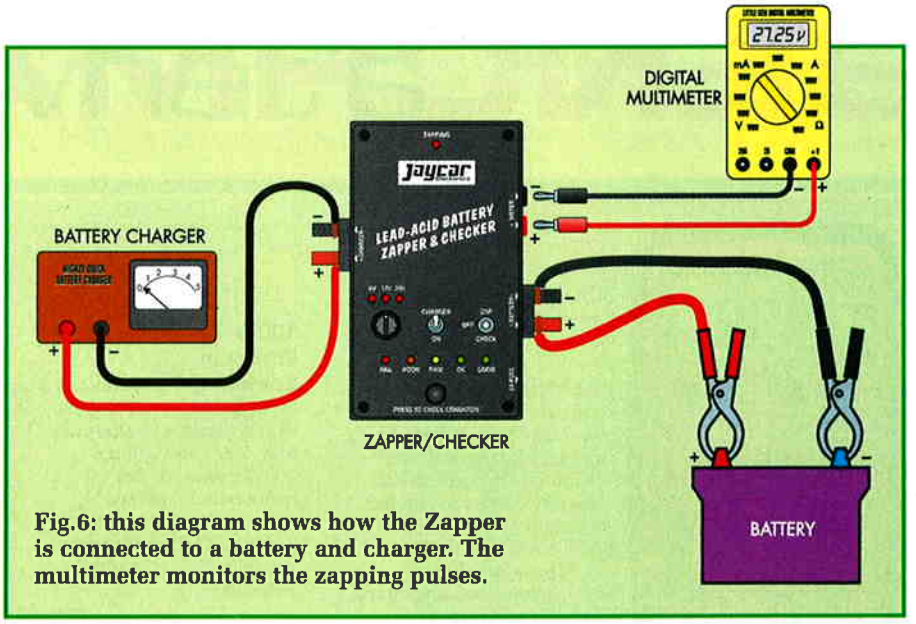


Fig.6: this diagram shows how the Zapper is connected to a battery and charger. The multimeter monitors the zapping pulses.

Machine screws can be fitted to the Zapper's charger terminals to provide handy contact points for the battery charger's alligator clip leads.

BENCHMARK May 2006

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Fig. 8 Solid Core Bell Wire

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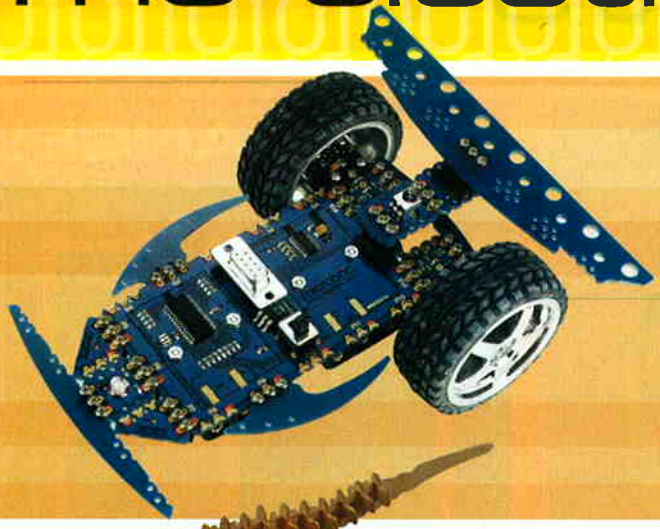
The electronics and



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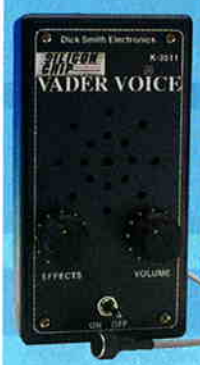

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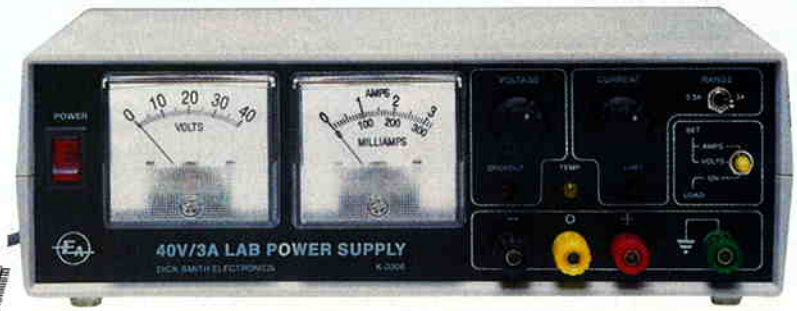

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The Electronic Control Unit for a four cylinder common rail BMW diesel. [BMW]

Diesel Engine Management

Part 2
by Julian Edgar

Last month we looked at the mechanical make-up of the common rail diesel fuel injection systems that have revolutionised diesel-powered cars.

The systems used extremely high fuel pressure, electronically controlled injectors and complex exhaust aftertreatment to provide very high specific torque outputs with low fuel consumption and low emissions.

But how does the electronic control system work? In this article we look at the electronics of the system.

Requirements

The engine management system in a diesel common rail engine needs to provide:

- Very high fuel injection pressures (up to 2000 Bar)
- Variation in injected fuel quantity, intake manifold pressure and start of injection to suit engine operating conditions
- Pre-injection and post-injection
- Temperature-dependent rich air/fuel ratio for starting
- Idle speed control independent of engine load
- Exhaust gas recirculation
- Long term precision

As with current petrol engine management systems, the driver no longer has direct control over the injected fuel quantity.

Instead, the movement of the accelerator pedal is treated as a torque request and the actual amount of fuel injected in response is dependent on the engine operating status, engine temperature, the likely affect on exhaust emissions, and the intervention by other car systems (eg traction control).

Figure 1 shows an overview of the inputs, outputs and internal processes in the Bosch common rail management system.

Management Functions

- ***Starting***

The injected fuel quantity and start of injection timing required for starting are primarily determined by engine coolant temperature and cranking speed.

Special strategies are employed for very cold weather starting, especially at high altitudes. In these conditions, the turbocharger operation may be suspended as its torque demand – al-

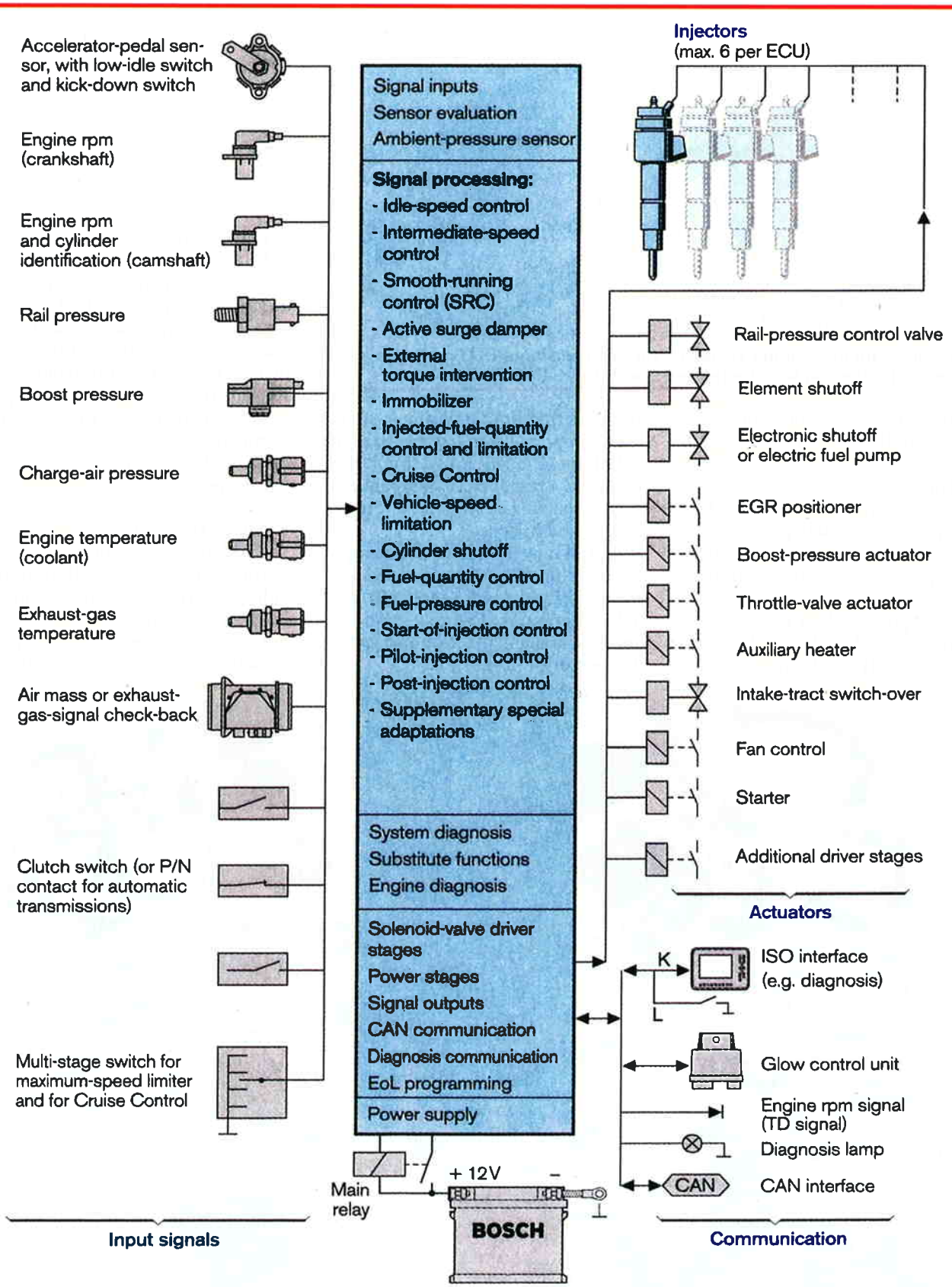


Fig.1: an overview of a common rail diesel engine management system. The input signals to the ECU are on the left and include accelerator pedal position, intake mass airflow, fuel rail pressure and engine speed. Not shown here but also often included is a wideband exhaust gas oxygen sensor. The outputs (right) include the control of the fuel injectors, exhaust gas recirculation (EGR) and fuel rail pressure. Inside the ECU (middle) control strategies are implemented for idle speed, smooth running control, quantity of fuel injected, starting point of injection, and many others. [Bosch]

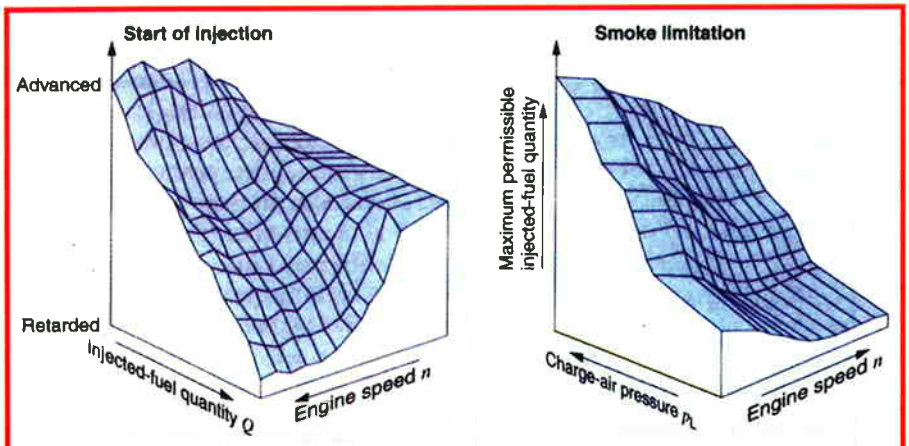


Fig.2: along with many other variables, three dimensional ECU maps are used for both injection start timing and smoke limitation. [Bosch]

though small – may be sufficiently great as to prevent the car from moving off.

- ***Driving***

In normal driving, the injected fuel quantity is determined primarily by the accelerator pedal sensor position, engine speed, fuel and intake air temperatures.

However, many other maps of data also have an effect on the fuel injection quantity actually used. These include strategies that limit emissions, smoke production, mechanical overloading and thermal overloading (including measured or modelled temperatures of the exhaust gas, coolant, oil, turbocharger and injectors).

Start of injection control is mapped as a function of engine speed, injected fuel quantity, coolant temperature and ambient pressure. Figure 2 shows example data maps for start of injection and smoke control.

- ***Idle Speed Control***

The set idle speed depends on engine coolant temperature, battery voltage and operation of the air conditioner. Idle speed is a closed loop function where the ECU monitors actual engine speed and continues to adjust fuel quantity until the desired speed is achieved.

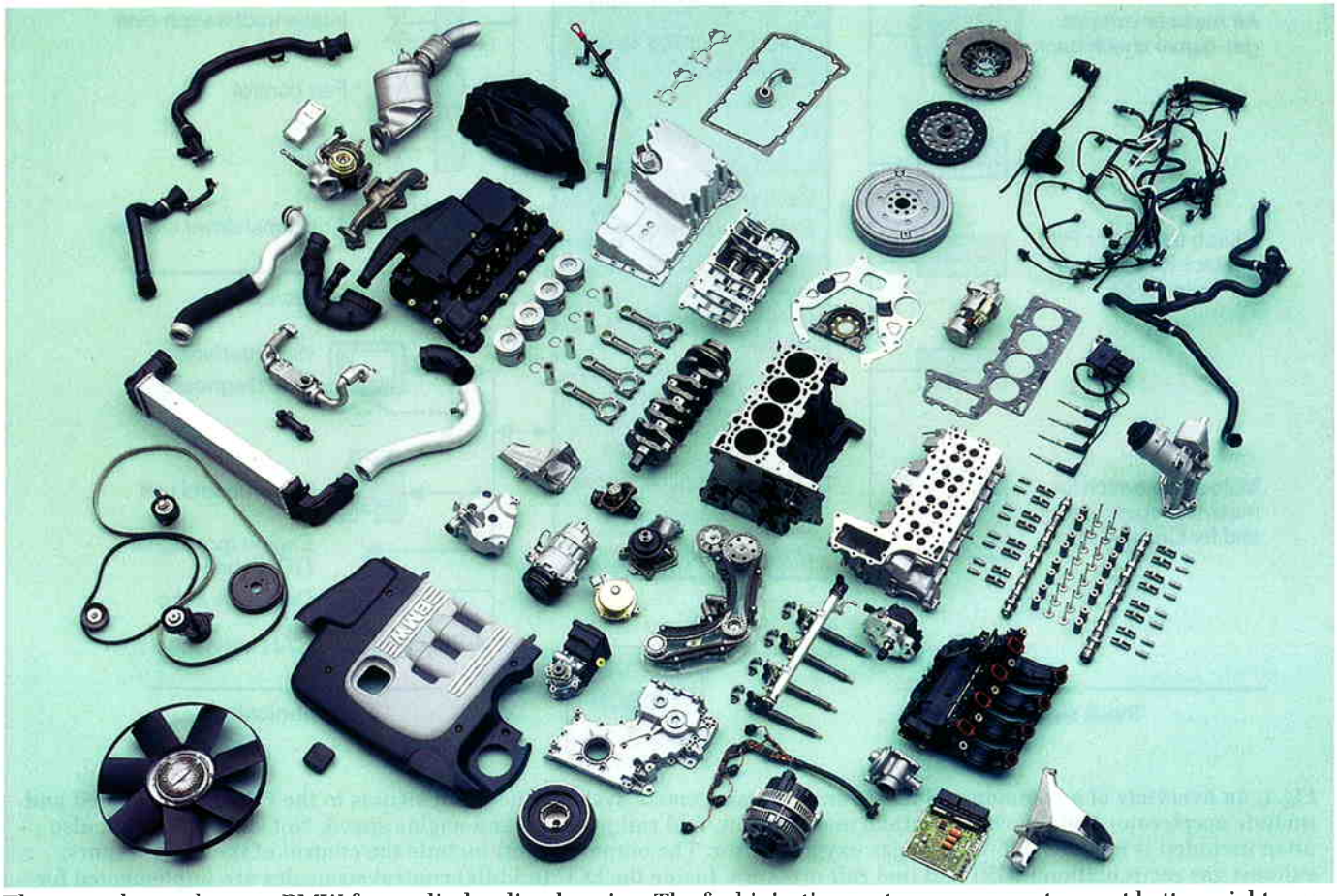
- ***Rev Limiter***

Unlike a petrol engine management system which usually cuts fuel abruptly when the rev limit is reached, a diesel engine management system progressively reduces the quantity of fuel injected as the engine speed exceeds the rpm at which peak power is developed. By the time maximum permitted engine speed has been reached, the quantity of fuel injected has dropped to zero.

- ***Surge Damping***

Sudden changes in engine torque output can result in oscillations in the vehicle's driveline. This is perceived by the vehicle occupants as unpleasant surges in acceleration.

Active Surge Damping reduces the



The parts that make up a BMW four cylinder diesel engine. The fuel injection system components are at bottom right – visible are the injectors and common rail, the high pressure pump and the ECU. [BMW]

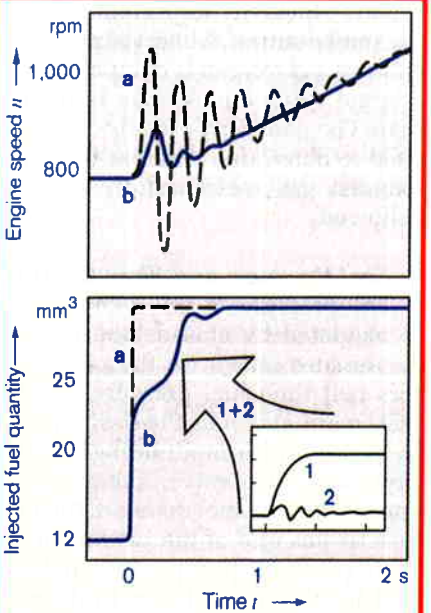


Fig.3: Surge Damping is used to prevent unwanted oscillations in acceleration. The top diagram shows the change in accelerations without surge damping (a) and with it (b). This alteration in car behaviour can be achieved in two ways. The lower diagram shows (1) the effect of electronic filtering of the accelerator pedal travel sensor output signal, and (2) the active correction of surge by increasing the injected fuel quantity when the engine speed drops and decreasing it when the speed increases. [Bosch]

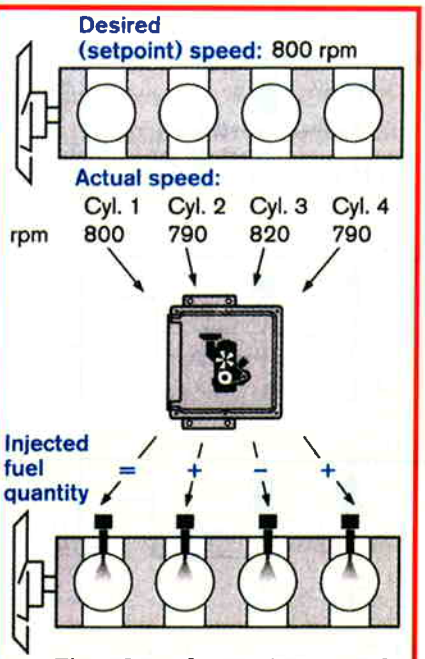


Fig.4: Smooth Running Control addresses the fact that the torque output of each cylinder is not identical. To counteract this, the system compares the engine speed immediately after a cylinder's injection with the average engine speed (in this case 800 rpm). If the speed has dropped, the fuel injection quantity for that cylinder is increased. If the engine speed is above the mean, the fuel injection quantity for that cylinder is decreased. [Bosch]

likelihood of these oscillations occurring. Two approaches can be taken.

In the first, any sudden movements of the accelerator pedal are filtered out, while in the second, the ECU detects that surging is occurring and actively counteracts it by increasing the injected fuel quantity when the engine speed drops and decreasing it when the speed increases. Figure 3 shows this process.

- ***Smooth Running Control***

Because of mechanical differences from cylinder to cylinder, the development of torque by each cylinder is not identical. This difference can result in rough running and increased emissions.

To counteract this, Smooth Running Control uses the fluctuation in engine speed to detect output torque variations. Specifically, the system compares the engine speed immediately after a cylinder's injection with the average engine speed. If the speed has dropped, the fuel injection quantity for that cylinder is increased. If the engine speed is above the mean, the fuel injection quantity for that cylinder is decreased. Figure 4 shows this process.

- ***Closed Loop Oxygen Sensor Control***

As with petrol management systems, diesel management system use oxygen sensor closed loop control. However, in diesel systems a broadband oxygen sensor is used that is capable of measuring air/fuel ratios as lean as 60:1. This Universal Lambda Sensor (abbreviation in German: LSU) comprises a combination of a Nernst concentration cell and an oxygen pump cell.

Because the LSU signal output is a function of exhaust gas oxygen concentration and exhaust gas pressure, the sensor output is compensated for variations in exhaust gas pressure. The LSU sensor output also changes over time and to compensate for this, when the engine is in over-run conditions, comparison is made between the measured oxygen concentration of the exhaust gas and the expected output of the sensor if it were sensing fresh air. Any difference is applied as a learned correction value.

Closed loop oxygen control is used for short- and long-term adaptation learning of the injected fuel quantity.

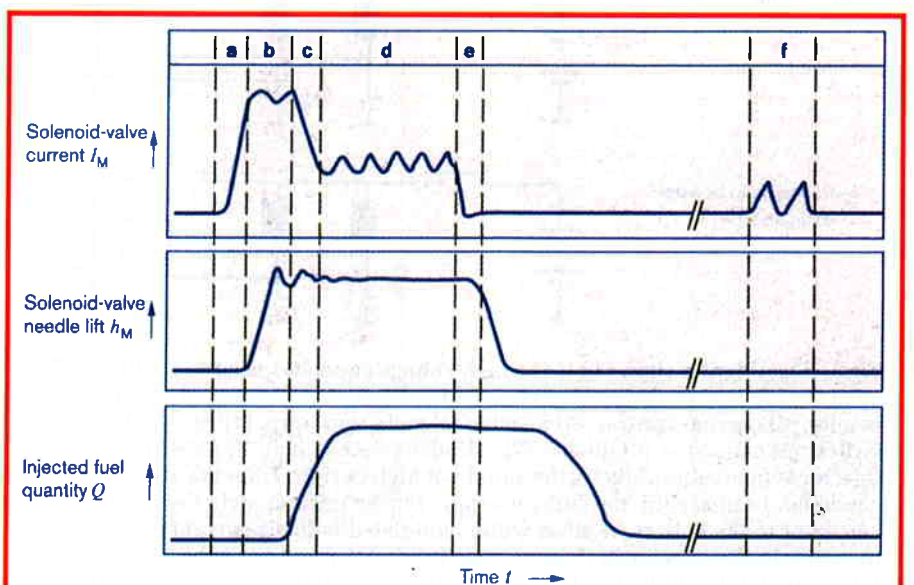


Fig.5: this diagram shows the relationship between solenoid valve (ie injector) current, solenoid valve needle lift and injected fuel quantity. At (a) the injector is opened with a rapidly rising (but controlled) rush of current, at (c) the current is decreased but is still sufficient to hold the injector open, at (e) the current is switched off and the injector closes. The sawtooth pattern of low current flow that can be seen at (f) is explained in Figure 6. [Bosch]

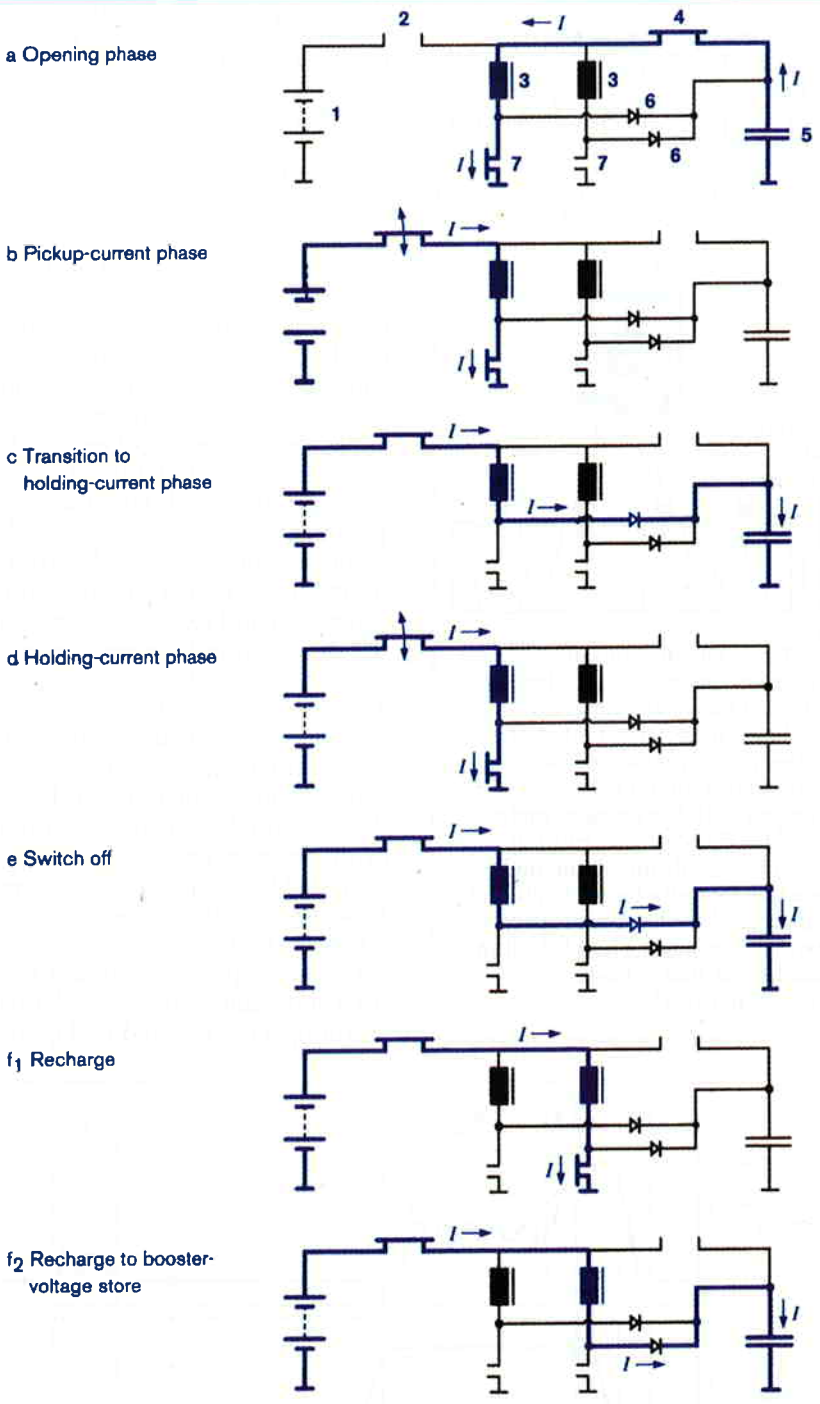


Fig.6: this diagram shows how the high voltage capacitor used to rapidly pull open the injector is also in turn charged by the injector's solenoid coil. (1) battery, (2) current control, (3) injector solenoid windings, (4) current boost switch, (5) capacitor, (6) diodes, (7) cylinder select switch. In phase (a), the injector is opened rapidly by the supply of high current from the 100V booster capacitor. In phase (b), the current supply for the injector switches from the capacitor to the battery. A pulse width modulated holding current is then used to maintain the injector in its open state (phase d) and during the transition to this phase (c), the inductive spike generated by the reduction in current through the injector is routed to the booster capacitor, so starting its recharging process. When the injector is switched off (phase e), the inductive spike is again routed to the booster capacitor. Between injector opening events, a sawtooth waveform is applied to the closed injector (phase f1 and f2). This current is insufficient to open the injector but the generated inductive spikes are used to further recharge the booster capacitor until it again reaches 100V. [Bosch]

This is especially important in limiting smoke output, where the measured exhaust gas oxygen is compared with a target value on a smoke limitation map. Oxygen sensor feedback is also used to determine whether the target exhaust gas recirculation is being achieved.

- ***Fuel Pressure and Flow Control***

The pressure in the common rail is regulated by closed loop control. A pressure sensor on the rail monitors real time fuel pressure and the ECU maintains it as the desired level by pulse width modulating the fuel pressure control valve. At high engine speeds but low fuel demand, the ECU deactivates one of the pistons in the high pressure pump. This reduces fuel heating in addition to decreasing the mechanical power drawn by the pump.

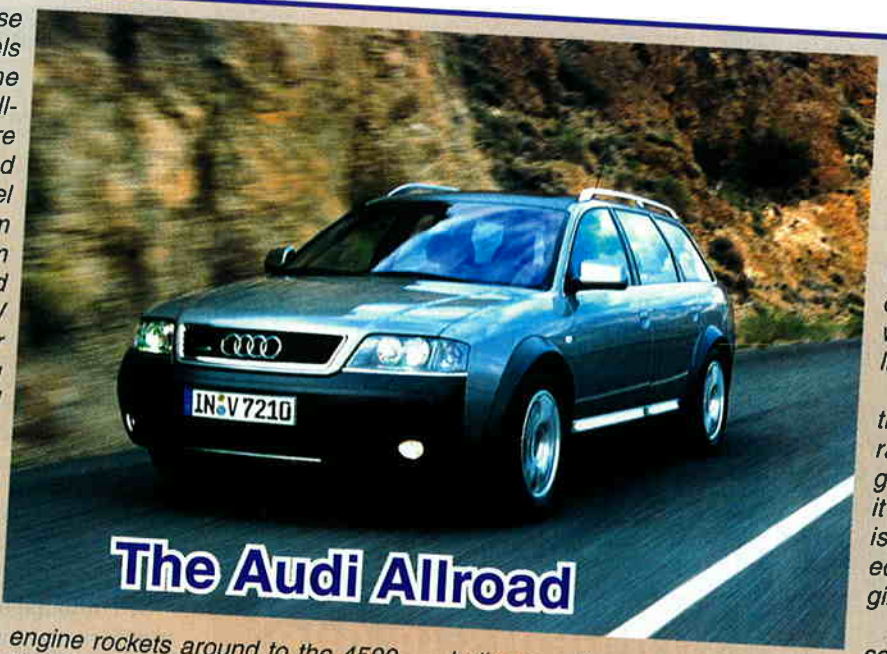
Other Management System Outputs

In addition to the control of the fuel injectors, the diesel engine management system can control

- Glow plugs for sub-zero starting conditions
- Glow plugs that heat the coolant, providing adequate cabin heating in cold climates

A cutaway view of a BMW common rail diesel 6-cylinder in-line engine. The electronically controlled fuel injectors can be seen at the top of each cylinder while one of the glow plugs (rarely used except in very cold ambient conditions) can be seen angled into the combustion chamber. [BMW]

The Audi Allroad



So what are these common rail diesels actually like on the road? The Audi Allroad uses a 2.5 litre turbocharged, injected and intercooled diesel engine. Its maximum torque is 370Nm from 1500-2500 rpm and peak power is 132kW at 4000 rpm. The car has a mass of 1825kg and uses a 5-speed automatic transmission.

Off the line there's a noticeable hesitation as the turbo builds boost, then – whoooosh – the torque arrives and the engine rockets around to the 4500 rpm redline, pulling hard all the way. The auto slides to the next ratio – which puts engine revs back in the middle of that torque plateau – and she's off again.

Audi claim 0-100 km/h in 10.2 seconds, but the rolling times are far faster than this standing start time would suggest. You really only notice the absence of top-end power when climbing long hills at high speed.

In a wide mix of driving biased more towards freeway than climbing mountains, we averaged 10.1 litres/100km.

And what about that horrible diesel rattle? There's no getting away from it – the TDi Allroad is noisier than the equivalent petrol engine version.

Despite extensive soundproofing – including a rubber bonnet seal right around the engine bay – a distinctly different engine note can be heard inside the cabin. It's more of a whine that a rattle – though passers-by hear a normal diesel. But at cruise the car is commendably quiet – the unusual engine note can really only be heard when accelerating.

- Switchable intake manifolds, where at low loads air is forced through turbulence ducts to provide better in-cylinder swirl
- Turbocharger boost pressure control
- Switching of radiator fans

Injector Operation

The triggering of the injector can be divided into five phases:

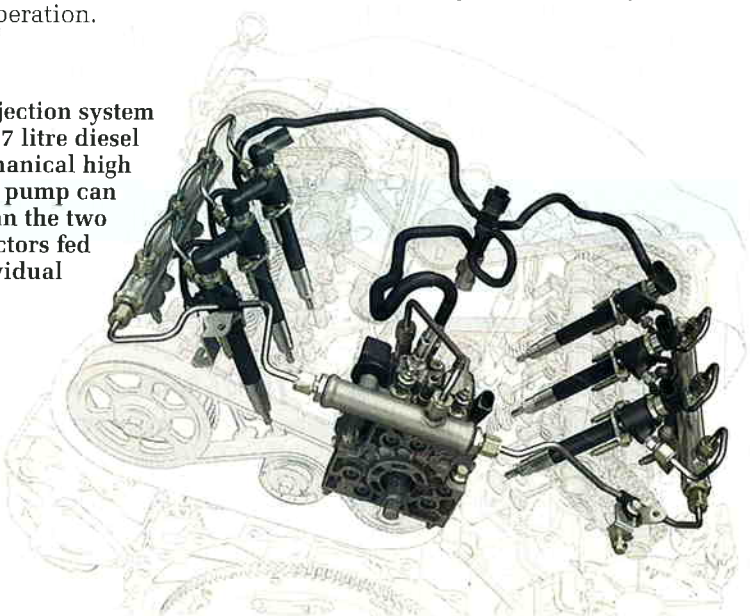
- In the first phase, the injector is opened rapidly by the supply of high current from a 100V booster capacitor. Peak current is limited to 20A and the rate of current increase is controlled to allow consistent injector opening times.
- The second phase is termed 'pick-up current'. In this phase, the current supply for the injector switches from the capacitor to the battery. In this phase, peak current continues to be limited to 20A.
- A 12A pulse width modulated holding current is then used to maintain the injector in its open state. The inductive spike generated by the reduction in current through the injector in the change from 'pick-up' to 'holding' phases is routed to the booster capacitor, so starting its recharge process.
- When the injector is switched off, the inductive spike is again routed to the booster capacitor.
- Between actual injector events, a sawtooth waveform is applied to the closed injector. The current used is insufficient to open the injector and the generated inductive spikes are used to further recharge the booster capacitors until they reach 100V.

Fig.5 shows the relationship between injector current, needle lift and fuel flow. Fig.6 shows the five phases of injector operation.

Conclusion

European car manufacturers and consumers have thrown their weight heavily behind passenger cars equipped with diesel engines.

The major improvement in specific torque outputs and the reduction in fuel consumption and emissions have been achieved with sophisticated electronic control of very high pressure, individually controlled injectors. SC



The direct injection system of a Jaguar 2.7 litre diesel V6. The mechanical high pressure fuel pump can be seen, as can the two banks of injectors fed by their individual fuel rails. [Jaguar]

This portable unit combines five measurement and stimulus tools to form a highly integrated electronics lab instrument. It connects to your PC via the USB port and features easy-to-use Windows software.

WITH THE RAPID advances in personal computer performance, their marriage to digital instrumentation seems a given. Add a PC with some clever software to a data acquisition "front end", and you get a high performance oscilloscope or other instrument, which could equal the specs of the more traditional stand-alone units at a fraction of the cost.

While there are several hurdles to be overcome before PC-based scopes hit gigasample territory for less than a few hundred dollars, an ever-increasing number of companies are nonetheless producing highly functional, low-cost units.

A good example is to be found in the new ELAB-080 from US-based company Dynon Instruments. This unit incorporates five virtual instruments in one: a 2-channel digital storage oscilloscope, 16-channel logic analyser, analog/digital arbitrary waveform generator, two programmable power supplies and two programmable clocks.

ELAB-080 At A Glance

- Digital storage oscilloscope: 80MS/s, 2-channel, 32k samples per channel.
- Logic analyser: 16-channel with DSO-synchronous sampling & triggering, 3.3V logic (5V tolerant).
- Arbitrary waveform generator: 100MS/s, 1 analog & five digital outputs, 64k samples.
- Programmable power supplies: two outputs, ±10V, 100mV increments, ±60mA current.
- Programmable clocks: 2 outputs, 1kHz-150MHz, 3.3V logic.

The DSO's vertical "sensitivity" is 10mV/div to 50mV/div using x1 probes. Horizontal scaling is adjustable from 2ns/div to 5s/div. Maximum measurable voltage is 4Vp-p with x1 probes and 50Vp-p with x10 probes, and triggering can be rising or falling with programmable level select.

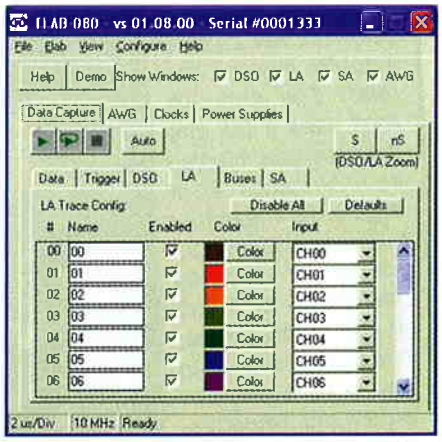

ELAB 080 - vs 01.08.00 - Serial #0001333
File Elab View Configure Help
Help Demo Show Windows: DSO LA SA AWG
Data Capture AWG Clocks Power Supplies
Auto
Data Trigger DSO LA Buses SA
LA Trace Config
Disable All Defaults
Name Enabled Color Input
00 01 02 03 04 05 06
CH00 CH01 CH02 CH03 CH04 CH05 CH06
2 us/Div 10 MHz Ready

Fig.1: all instruments are controlled from this main window. You certainly can't get lost using this simple tabbed menu layout!

It's unusual to find this many instruments in one package, which explains why it's referred to as a "PC-hosted electronics lab"! Also unusual at this price is the oscilloscope's maximum sampling rate of 80MS/s (80 million samples/sec), which is shared with the logic analyser (they operate synchronously). Conversely, the arbitrary waveform generator (AWG) has an independent clock and can operate at up to 100MS/s.

The unit is supplied in a folded steel case measuring 184 x 125 x 42mm and weighing only 635g. Power is provided by a hefty (by comparison) external AC adapter, which generates ±16V and 5V outputs.

Three BNC connectors are provided on the front panel; two for the oscilloscope inputs and one for the AWG's analog output. Two conventional 60MHz probe kits are included in the package.

All remaining I/O, including the logic analyser inputs, digital outputs, clocks and power supplies are made available via rows of 0.63mm square header pins, spaced 2.54mm apart. These are recessed below the surface of the front panel for protection. The package includes a plug-in wiring harness terminated with individual female push-on receptacles that will mate with Pomona 5360 SMD clips (not included) or similar.

Software

All five instruments are driven by one software application, which runs on Windows 98SE, Me, 2000 or XP. A main control window (see Fig.1) allows you to configure each instrument.

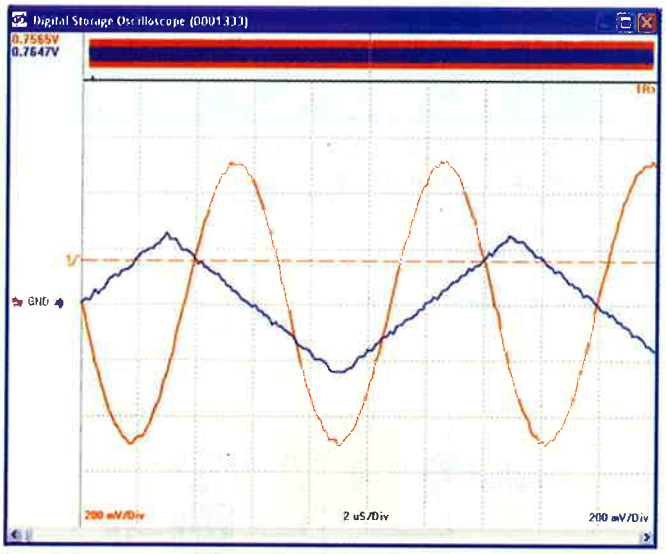


Fig.2: basic settings like horizontal/vertical zoom & trigger level can be changed in the oscilloscope window.

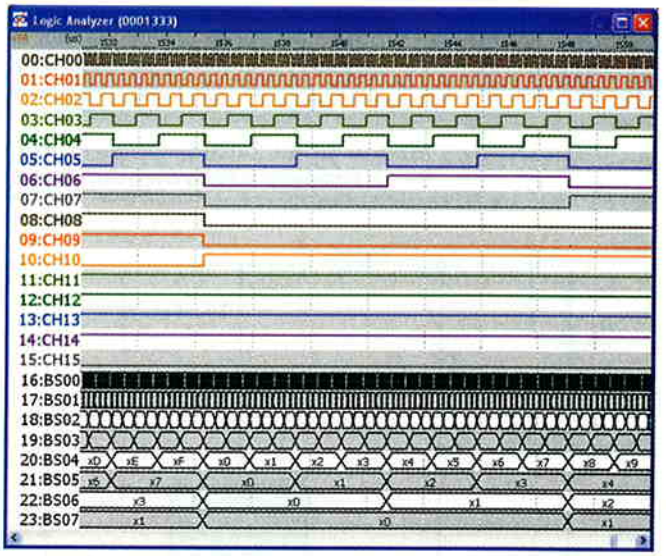


Fig.3: the colour for each logic analyser trace can be altered to taste and you can zoom right in with two mouse clicks if needed. Channels can also be grouped into buses, making interpretation easier.

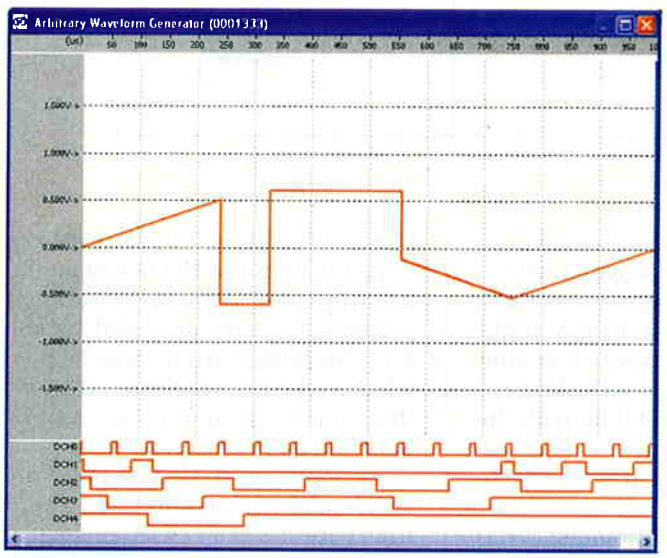


Fig.4: roll your own waveforms directly in the AWG window by clicking and dragging the trace. Up to 65,536 points can be defined at 0.15Hz playback, but only 10 points at 10MHz.

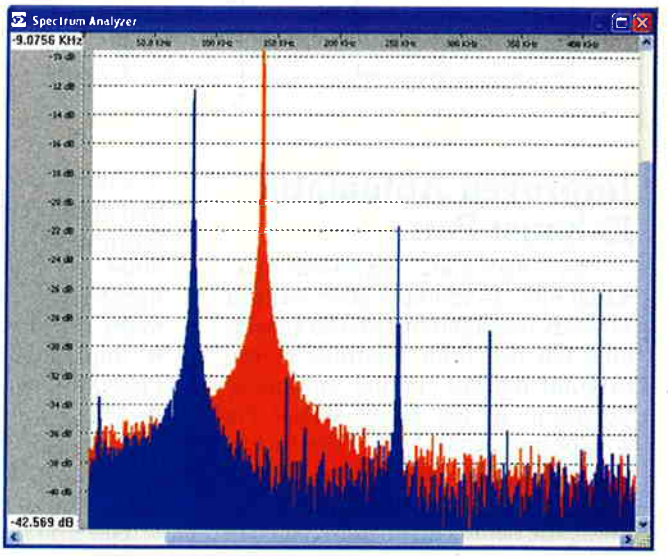


Fig.5: the most recent version of the software includes a spectrum analyser display.

For example, the probe gain, coupling type, X-axis zoom and Y-axis position are all set on the "DSO" tab. As well, options are available to show or hide each instrument's display window.

Several instrument functions can be controlled from directly within the individual display windows. In the case of the oscilloscope, the horizontal and vertical axis displays, timing cursors and trigger voltage level can all be changed by right-clicking in the window (Fig.2).

Similar functionality is available in the logic analyser's window (Fig.3). Traces for individual channels can be shown or hidden, as can the two timing cursors. Like the 'scope, the horizontal zoom level can be set from 2ns/div to 5s/div.

Also of note is the ability to create or edit a waveform directly in the AWG's display window (Fig.4). Basic waveforms (sine, square, etc.) can be used as a starting point, or you can import a waveform captured from the DSO.

Naturally, all instrument settings can be saved to a file for later retrieval; so multiple setups are easily accommodated. Oscilloscope/logic analyser and AWG data can also be saved and loaded from disk, making later analysis possible.

Summary

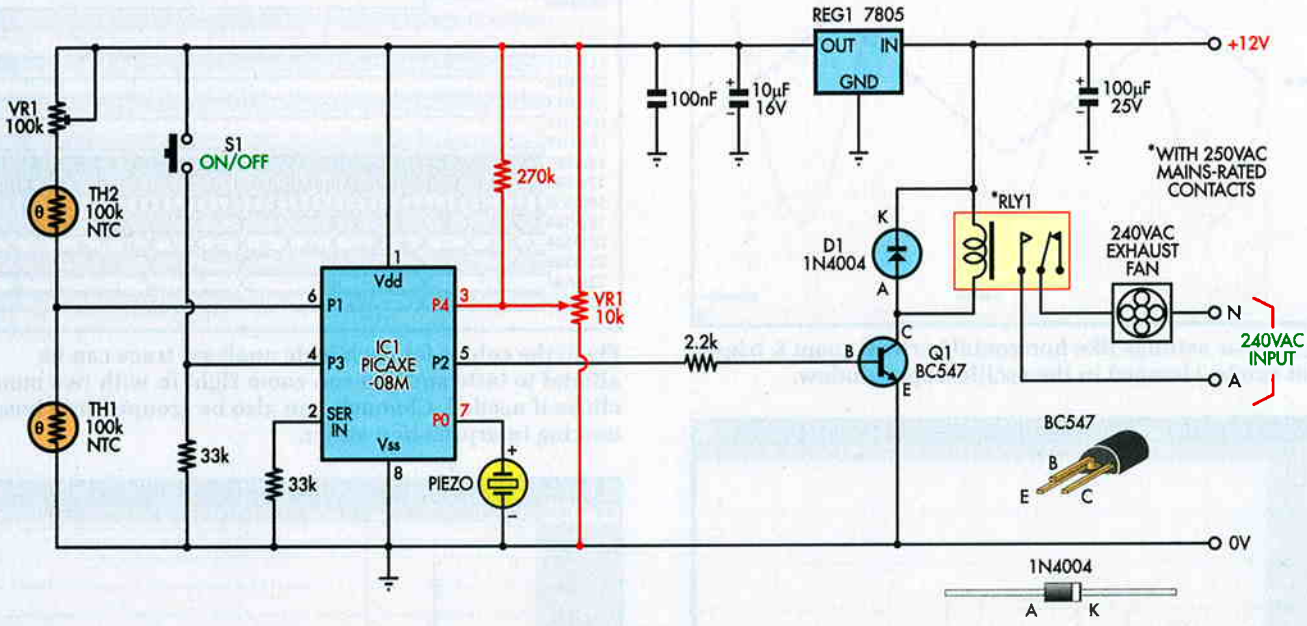
The ELAB-080 combines a number of general-purpose instruments into one portable, low-cost package. The product will be of interest to small companies and individuals who cannot afford the high prices of stand-alone instruments.

For all of the technical details, point your browser to **www.dynoninstruments.com**. The ELAB software includes a "demo" mode with sample data, so you can download and try it yourself to get a feel for the product.

The ELAB-080 is available from Australian distributor Digital Graphics, also on the web at **www.digitalgraphics.com.au** or phone (02) 4567 8999. Price at time of publication was $740 plus GST. **SC**

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Improved Automatic Exhaust Fan

The "Automatic Bathroom Exhaust Fan" in the May 2005 edition is easily modified to provide adjustable fan run time. Features of the original design include automatic detection of hot water usage via a pipe-mounted NTC thermistor, along with single pushbutton on/off control. Fan run time was fixed but using the details given here, you can add a potentiometer to give a useful adjustment range of 4-10 minutes.

Several modifications to the original circuit are also required. We've reproduced the circuit from May 2004 for convenience and highlighted the alterations in red. In summary, the changes are as follows:

- Replace the PICAXE-08 with the PICAXE-08M version.
- Move the piezo transducer to *output0* (pin 7).
- Add a 10kΩ potentiometer (VR1) and 270kΩ resistor.

The updated program allows for the piezo relocation and includes commands for reading the potentiometer's voltage (wiper position), which is then used to calculate the fan run time. With the additional program memory provided by the PICAXE-08M, it would also be possible to add beeps at the quarter and three-quarter timing points and/or appropriate musical passages.

As mentioned in the previous article, the unit should be powered from batteries or a 12V DC plugpack, while an electrician should handle all of the 240VAC wiring.

W.A. Fitzsimons,
Mount Eliza, Vic. ($40)

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As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But now there are four more reasons to send in your circuit idea. Each month, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100 Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd **www.peakelec.co.uk**

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You can either email your idea to silchip@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.

Listing 1: Bathroom Exhaust Fan Controller

```
' Improved Bathroom Exhaust Fan Controller - 13.9.2005
' PICAXE-08M

mainloop:
  readadc 1,b0                  'read voltage divider
  if b0<96 then timer1          'hot water temperature turns the fan on
  if pin3=1 then timer1         'momentary switch takes P3 high
  goto mainloop

timer1:
  b1=0                          'reset delay flag
  readadc 4,b5                  'reads timer setting
  w3=224-90                     'calculating b2 range =90+(b5*(224-90))/256
  w4=b5*w3
  w4=w4+1                       'ensures that zero is not used in next calc
  b5=w4/256
  b5=90+b5                      'value for b2's for..next loop
  high 2                        'turn fan on
  pause 2000                    'cloaking for P3

timer2:
  for b4=1 to 8                 'start timer
    if pin3=1 then fanoff1
    for b3=1 to 243
      if pin3=1 then fanoff1
      for b2=1 to b5            'time range of 4 to 10 minutes
        if pin3=1 then fanoff1
        next b2
    next b3
    if b4=4 then beep1          '1/2 way reminder
    if b4=8 then beep2          'for timer completion
beep:
  next b4
goto fanoff

' One beep on P0 or turn fan off after delay

beep1:
if b1=1 then fanoff             'after delay period turn fan off
pulsout 0,65535                 '1 beep on P0
goto beep

beep2:                          '2 beeps on P0
pulsout 0,65535
pause 1000
pulsout 0,65535
goto beep

fanoff1:
if b1=1 then timer1             'if delay flag is set then turn fan on
readadc 1,b0
if b0>96 then fanoff            'no delay required
if b0=96 then fanoff            'no delay required
b1=1                            'set delay flag
low 2                           'stop fan
pause 2000                      'cloaking for P3
goto timer2

fanoff:
b1=0                            'reset delay flag
low 2                           'stop fan
pause 2000                      'cloaking for P3
goto mainloop
```


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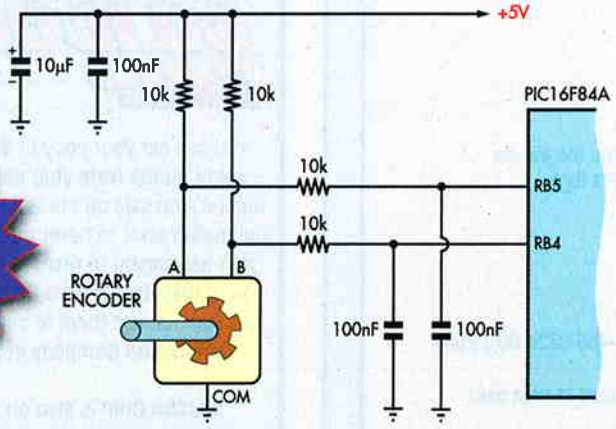


Bryce Templeton is this month's winner of a Peak Atlas Test Instrument

A Rotary Encoder For Your PIC project

Here's a useful code fragment that demonstrates how to add a rotary encoder to your next PIC-based project. Rotary encoders ("jog wheels") can greatly simplify the user interface of any project that requires multiple buttons on the front panel.

For instance, a jog wheel and just one button can replace the hours, minutes, up and down buttons on a clock. It could also be used to select menu items from a list, or as the input to a digital volume control. Encoders are also available with momentary switches built-in, making the interface even simpler!

The encoder should be of a type that has one cycle per indent. For example, units with 24 indents and 24 cycles are suitable but 6 cycles and 24 indents are not.

The selected PIC micro should include the port B "interrupt on change" feature, which sets INTCON bit 0 when port B inputs RB7-RB4 change. In this example, the "A" terminal of the encoder is connected to RB5 and the "B" terminal to RB4. The encoder is wired to pull the micro inputs low, so when it is at a detent both inputs are high. Although not listed here, port B must be set up accordingly in the initialisation section of your program.

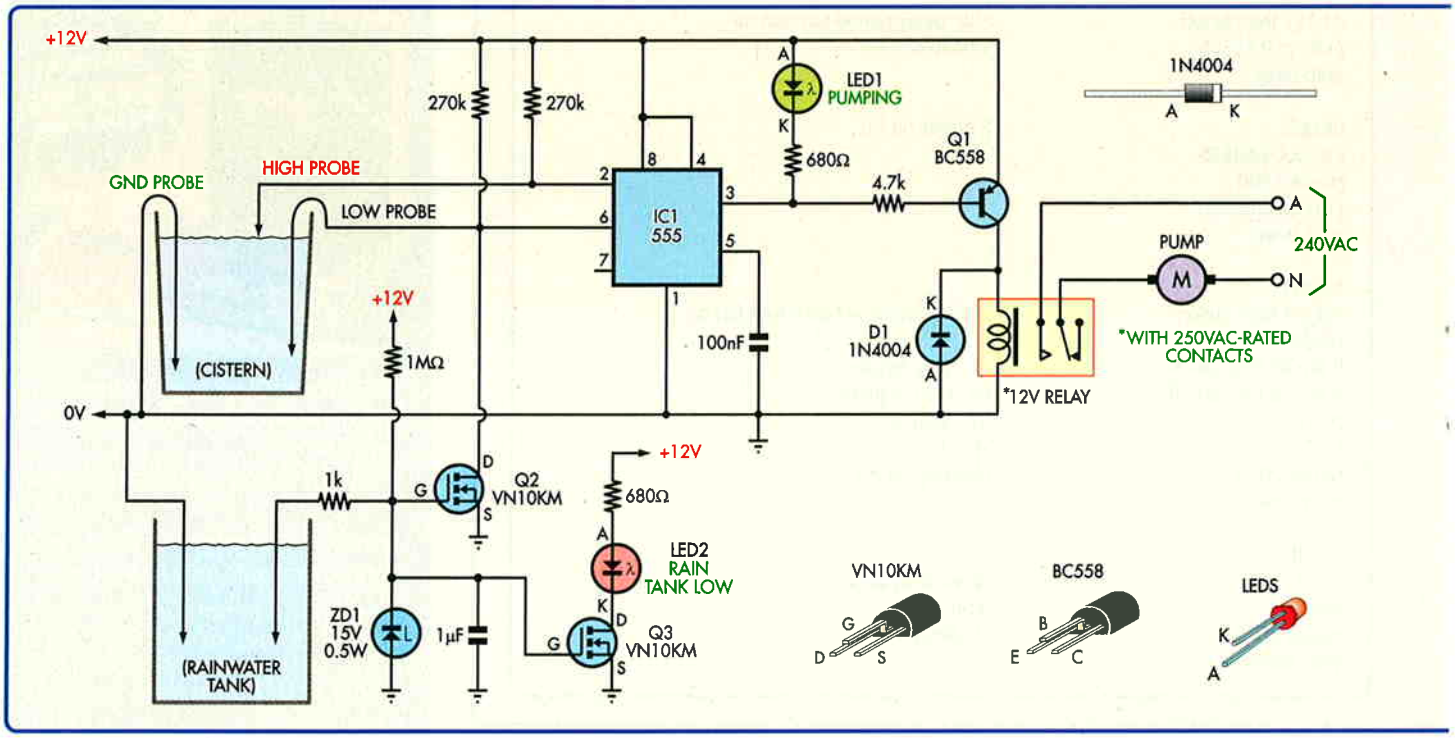
The interrupt flag is polled for encoder transitions on the port pins, so all interrupts must be disabled (clear INTCON bit 7) before executing this code. Transitions on RB6 & RB7 will also set INTCON bit 0, so if these bits are not used they should be set to outputs to exclude them from the interrupt on change function.

The following registers are used:

jogtmr – contact bounce timer
result – the number to be adjusted is stored here
temp – a temporary register (can be shared)
flags – bit 1 = adjust mode
bit 2 = jog timer
bit 3 = first pass
bit 4 = jog done

As can be seen in the *jog* section of the program, the encoder wheel only becomes active after the system had been placed in "adjust" mode, which is easily accomplish by setting bit 1 of the *flags* register. On the author's system, this flag is set when a button is pressed.

All exits from this short program go to a label called *adjust*. Any label could have been used here, because *adjust* is really just the start of the next routine to be executed in line.



Listing 2: PIC-Based Rotary Encoder

```
jog:
   btfsc    flags1,1     ;adjust flag set?
   goto     jogok        ;do jog if set
   bcf      intcon,0     ;clear jog moved flag
   goto     main         ;no jog if not in adjust mode

jogok:
   btfss    intcon,0     ;jog changed?
   goto     adjust       ;exit if not
   btfsc    flags1,2     ;check timer flag
   goto     dtmr
   btfsc    portb,5      ;check 'A' terminal
   goto     ahigh        ;if high, skip
   btfsc    flags1,3     ;if low, check 1st pass flag
   goto     adjust       ;if set, exit
   bsf      flags1,3     ;otherwise, set 1st pass flag..
   bsf      flags1,2     ;..& timer flag..
   goto     adjust       ;..& exit

dtmr:
   decfsz   jogtmr,f     ;dec jog timer
   goto     adjust       ;if not=0, exit
   bcf      flags1,2     ;if=0,clear flag
   movlw    0x03         ;reload timer
   movwf    jogtmr
   goto     adjust       ;exit

ahigh:
   btfss    flags1,3     ;check 1st pass flag
   goto     adjust       ;if clear,exit
   movf     portb,w      ;if 2nd high, port b..
   movwf    temp1        ;.. to temp 1
   bcf      intcon,0     ;clear flag
   bsf      flags1,4     ;set jog done flag
   bcf      flags1,3     ;clear 1st pass flag
   btfsc    temp1,4      ;check 'B' terminal
   goto     bset
   incf     result,f     ;if clear inc result
   goto     adjust       ;& exit

bset:
   decf     result,f     ;if set dec result
   goto     adjust       ;do adjust
```

We'd expect that it would be the code that you've written to process the results, if any.

In use, the number to be modified is loaded into the *result* register and each pass through the program polls the INTCON register bit 0. Once this bit is set, indicating that the jog wheel has been turned, the program polls the "A" terminal of the encoder on RB5 until it goes low and then returns high again. After a short delay to allow for contact bounce, port B is copied into the *temp* register. This prevents contact noise affecting the result.

The direction of the jog wheel is then determined by the state of the "B" terminal (now in bit 4 of the *temp* register) and the *result* register is incremented or decremented as appropriate. The "jog done" flag is then set to indicate to the following code that the *result* register has been modified.

Finally, note that rotary encoders can be obtained from Farnell – see **www.farnellinone.com.au**.

Bryce Templeton,
via email.

Tank To Cistern Pump

While similar to the "Cheap Pump Controller" described in Circuit Notebook, August 2005, this slightly more elaborate unit pumps water from a rainwater tank to fill a cistern. As before, it uses a low-cost water feature pump, which is switched with a 240VAC-rated relay.

When the toilet is flushed, the water level drops below the "low" probe, causing the threshold input (pin 6) of IC1 (555) to swing high. Its output (pin 3) immediately goes low, biasing Q1 on, energising the relay and starting the pump.

When the water level subsequently reaches the "high" probe, IC1's trigger input (pin 2) is pulled towards ground. The output thus switches high and turns off the relay.

The probe connected to the gate of Q2 monitors the rainwater level in the tank. When the probe is immersed, Q2 is switched off and the remainer of the circuit is unaffected. Conversely, when the probe is exposed, Q2 is switched on via the 1MΩ pull-up resistor. This holds the 555's threshold input low and thus prevents the pump from starting.

A second MOSFET (Q3) and LED function as a low water level indicator. Zener diode ZD1, the 1kΩ resistor and 1µF capacitor common to both gate circuits protect the MOSFETs from static discharge and noise pickup.

Note that since the water is held at ground potential, stainless steel probes should be used to slow corrosion.

Geoff Coppa,
Elanora, Qld. ($35)

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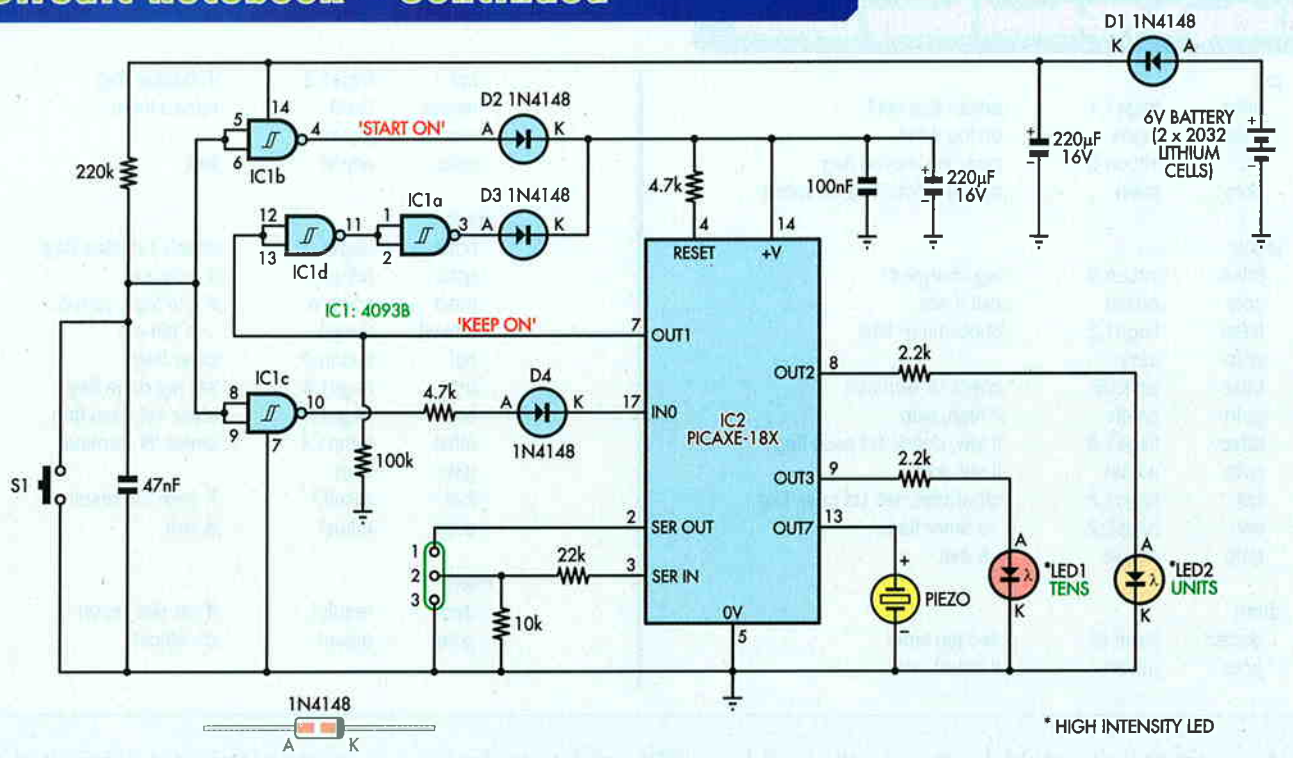

PICAXE-Powered Pocket Timer

Here's a simple, easy to build pocket-sized timer with just one pushbutton switch and two LEDs. It's based on a PICAXE-18X micro, a 4093 quad Schmitt NAND gate and a few discrete components.

Together with a 220kΩ resistor and 47nF capacitor, one gate of the 4093 (IC1c) is used to clean up the signal from the switch (S1) before it is applied to *input0* (pin 17) of the micro.

Pressing the switch pulls the two inputs of IC1b low, driving the output high and powering the PICAXE micro via diode D2. Assuming initial conditions, the BASIC program begins execution and immediately sets *output1* (pin 7) high, which – via IC1d, IC1a and D3 – also powers the PICAXE. This keeps the power on after the switch is released, removing the need for a separate on/off switch.

With the program now running, the "tens" LED lights. Pushing the switch while this LED is on increments the tens-of-minutes component of the timing period. Each button press is sensed via *input0* and accumulated in a program variable.

After five seconds, the "tens" LED goes out and the "units" LED lights. Pushing the switch now increments the minutes component of the timing period, with the total count accumulated in another program variable.

For example, if you were to push twice while the tens LED is lit and twice while the units LED is lit, the program will register a time period of 22 minutes. Note that if you want less than 10 minutes, don't push the switch while the tens LED is on.

Let's say you've selected 22 minutes. After the "units" LED goes out, the unit will display the time selected by flashing the "tens" LED twice and the "units" LED twice, followed by a short beep to indicate that the timing period has begun. The "tens" LED flashes every second during the countdown. When there are less than five minutes left, both LEDs light alternately. When there is less than one minute left, the "units" LED flashes. During the last 10s, both LEDs flash and the piezo sounder ticks each second. The unit then "rings" to indicate that the time has expired.

If the switch is held in for at least 3s during the timing period, the timing will be interrupted and a short "beep" will be heard. The unit then displays (via the LEDs) the number of minutes that are remaining, using the code mentioned earlier. The PICAXE then powers itself off by setting *output1* low.

Counts up, too!

If the switch isn't pressed while either the "tens" or "units" LEDs are lit, then after the usual 5-second wait, both LEDs will light. Pressing the switch at this point places the unit in "count-up" mode.

This mode has a maximum time period of two hours and is set identically to the count down mode above. During the first hour the "units" LED will flash. At one hour the unit gives a short beep and for the next hour the "tens" LED will flash. After two hours the unit beeps twice and then turns off.

If the button is held in for more than three seconds at any time during this mode, the timing stops and the LEDs display the elapsed time – just add the tens indication (x10) and the units indication. The unit then turns off.

Note: the BASIC program (ptimer.bas) could not be reproduced here due to space restrictions but will be available for free download from the SILICON CHIP website.

Eric Rodda,
Marion, SA. ($40)

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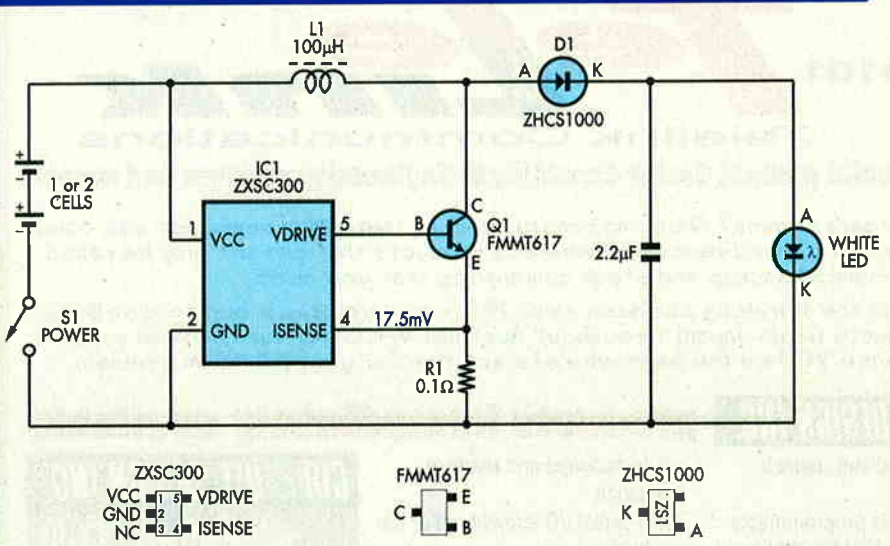

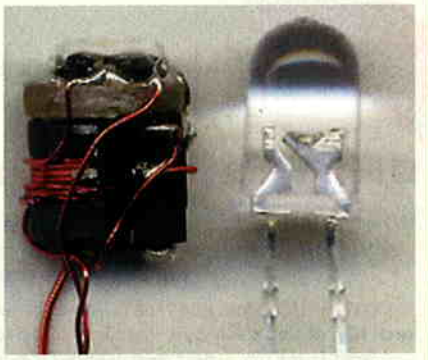

Fig.1: the ZXSC300 can be mounted on a circular section of PC board, with the remaining parts glued beneath the disc. All wiring is point-to-point using light gauge copper wire, the result being only slightly larger than a 5mm LED.

Fig.2: the assembled module sits nicely between the leads of an 8mm LED.

Fig.3: a 3-LED version can be built with only minor component variations. See the Zetex application notes at www.zetex.com for more information.

Miniature LED Torch Bulbs

LED torch bulb replacements are becoming more common but making your own can be fun and challenging. You'll need a steady hand and a lot of patience to work with the requisite miniature components, though!

This design uses a ZXSC300 step-up DC-DC converter IC to make a 2-cell to single white LED driver. It's essentially the same as the example in the Zetex datasheet (see www.zetex.com), and can be assembled into a tiny module for fitting inside a standard torch bulb housing.

The ZXSC300 doesn't directly regulate LED current. Instead, the peak current is limited by monitoring the voltage across a small resistor in series with the transistor's emitter lead. When this voltage reaches 19mV, the transistor is switched off and the "on" period terminates.

In common with all inductive step-up converters, the energy stored in the inductor is transferred to the load and output capacitor via the diode (D1) during the "off" period, which in the ZXSC300 is fixed at 1.7µs. Q1 is then switched back on and the cycle repeats. The frequency of operation is thus determined by the time it takes for the inductor current to ramp up to the specified value, which is related to both the inductance and the supply voltage.

All components must be surface-mount types if the completed module is to fit in a bulb housing. The sense resistor (R1) can be a standard 0603 or 0805 case size (eg, Farnell 806-7694). Alternatively, it could be constructed from a short length of Cuprothal resistance wire (available from Dick Smith Electronics) – taking into account that it would need to be fine-tuned when in place.

The ZXSC300 driver, transistor and diode are also available from Farnell, on line at **www.farnel-linone.com.au** or phone 1300 361 005. The 2.2µF output capacitor must be a ceramic type and could be made by stacking two 1µF types (eg. Altronics R-8650). The inductor may prove a little harder to source. It can be wound on just about any ferrite drum or rod that is small enough for the job. For highest efficiency, aim for a winding resistance of 0.5Ω or less.

Peter Dixon,
Chippendale, NSW. ($35)

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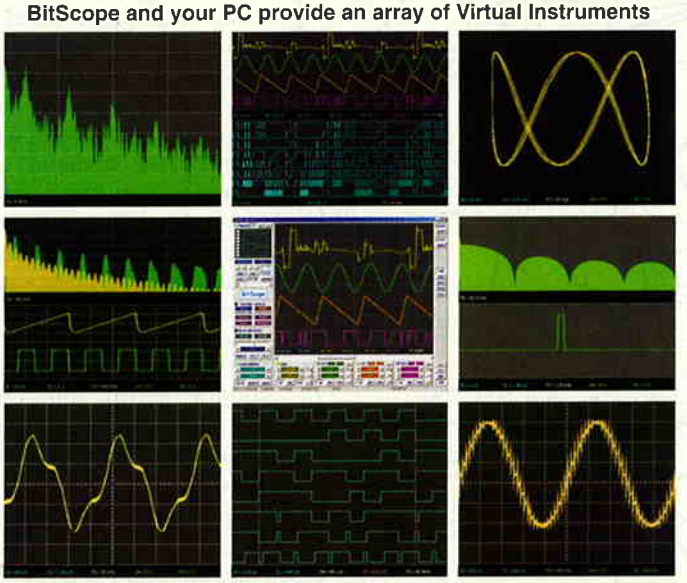

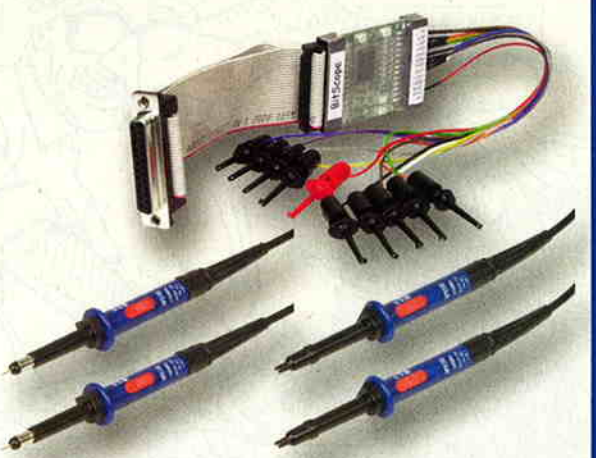

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SERVICEMAN'S LOG

The one-day TV technician

TV servicing is difficult enough without getting caught out by my own carelessness. Nor does it help to have one of my smart-alec colleagues rub salt into the wound.

I had a 2002 Sony PFM-42B2E flat panel plasma monitor come in with lines on the screen. This unit uses a Fujitsu PDP (plasma display panel). Fortunately, we had another identical set which had just been fixed and was on soak test, so we were able to swap modules and isolate the problem to the B Y-SUS board.

As described in a previous article, when working on these sets, we use the cardboard packaging that protects new plasma screens. The raised foam blocks glued onto this cardboard support the screen, while fragments of mirror tiles placed between the blocks enable us to observe what is happening on the screen during the course of the repair.

A small problem is what to do with the enormous amount of screws and hardware that accumulate as you strip down the machine to access the boards. Most times, you have to have an array of plastic boxes to put all this stuff into. Unfortunately, with the pressure of work and the demand for quicker and quicker service, the screws are invariably left resting on the back face of the plasma panel.

In this case, I was under pressure and being distracted by a colleague who has a strong accent and can sometimes be difficult to comprehend. Anyway, I unscrewed the metal screening cover and instead of putting it to one side, I left it lying on top of the power supply (Switching Regulator APS-179). And as you can probably guess, when I put the new board in, I switched the set on to check whether all was OK and completely forgot about this screen.

Of course, that was a big mistake. The metal screen shorted out one of the live heatsinks to an earthed heatsink, which completely killed the set.

My colleague thought that this was hilarious. "Mate", he said with this heavy accent, "you know why you are called the wonder technician? Because you are one day technician, no? Ha, ha!"

Oh well, humour is all in the eye of the beholder. One day, I'll give him his "one day technician" stuff right back in his face!

OK, so I'd started with a working plasma panel, got it to give a good picture and then, because of my carelessness, had made it to stop working altogether! However, it really wasn't that bad – power was getting into the board and some voltages were present. What's more, there were no obvious burnt components, nor had there been any major noises or explosions when it failed.

Encouraged by this, I removed the board and checked all likely fuses and fusible resistors. Nothing was immediately obvious until I

~I WAS UNDER PRESSURE & BEING DISTRACTED BY A OLLEAGUE WHOSE THICK ACCENT AN BE HARD TO COMPREHEND...
MAATE...
Voy Haf1
Noddin>ЯΠZZ
HoppinDA$$YET?
HOH! HOH!
*Translation not available
ENORMOUS AMOUNT OF SCREWS AND HARDWARE
SONY PFM-42B2E FLAT PANEL PLASMA GADGET TRAY
SWITCHING REGULATOR APS-179
METAL SCREENING COVER
PHILIPS HEAD (DIGITAL AXE (AGAIN))

measured R101, a 10Ω resistor, which was open circuit. Replacing it fixed the problem and I was back in business.

But I was lucky – you really can't afford to be careless or complacent when working with this kind of gear. And I'll remember my colleague's "one day tech" jibe.

Storm damage

TV sets hit in electrical storms are always dodgy – especially when it comes to warranty claims later. Lightning, being the erratic animal it is, can damage all sorts of odd circuits in a set, causing all sorts of bizarre trouble. And it's not just the parts that immediately fail that cause problems. Many other parts can be put under so much strain that they barely survive but then fail later.

Recently, I had a Sony KV-E29SN11 (BG1L chassis) which was dead after an electrical storm. The switchmode power supply was still working, though its output was low.

I removed the screen covers over the microcontroller and found that the 5-pin 5V IC regulator (IC601, L78LR050-MA) had burnt up, creating a hole through the board. I also found that a 22Ω 2W resistor had been fitted where link JW158 is shown on the circuit. This resistor had been getting very hot from the current it feeds to IC601.

Further up the food chain, I found that Q601 (2SA1315-Y) and R606 (18Ω) were similarly getting hot supplying current for IC601. Interestingly, this is only a back-up circuit for the main 11V rail that also feeds IC601 via a diode. This back-up circuit is also part of the power-on circuit and the 135V control circuit (which caused the 135V rail to drop).

I replaced all the parts and though I had some success, the results still weren't satisfactory, with too much current still being drawn – probably by faulty internal diodes and zener diodes in the microprocessor IC set on the 5V rail. In the end, this set was written off and the client got a new one with the insurance money.

An easy intermittent

A Chinese-built 2002 AWA W6900S/SF MkII came in with an intermittent no picture fault.

Of course it took a very long time for the fault to re-occur and as luck would have it, it only appeared just after we had told the client to come and collect it. Fortunately, it was an easy fix; the CRT filaments were intermittent and the fault was traced to a hairline fracture on R920, the 1Ω series resistor from the flyback transformer to the CRT heaters.

I wish that all intermittent faults were as easy as this.

Doing a Lazarus

A newish Sanyo WF2-00 (EB7-A32 chassis) came in DOA (dead on arrival) and still under warranty. Our job was to raise it from the dead – just like Lazarus.

Anyway, the set's switchmode power supply had spat the dummy, blowing chopper transistor Q613 (2SC4429), its driver (Q612, 2SC3807) and the surge resistor (R695, 1.8kΩ 7W). These parts were all replaced and the set indeed rose from the dead.

The only awkward part of this miracle was that its OSD was in a foreign tongue. I didn't have the instruction book but I struggled on with the menu before I worked out that it was stuck in Croatian! Once I knew what I was doing, I was able to set up the tuning for the local stations.

Items Covered This Month

- Sony PFM-42B2E plasma monitor
- Sony KV-E29SN11 TV set (BG1L chassis)
- AWA W6900S/SF MkII TV set
- Sanyo WF2-00 TV set (EB7-A32 chassis)
- LG CA-20F898 TV set (MC-994A chassis)
- Panasonic Dimension 4 Genius Convection Microwave oven NN-C855B
- Panasonic PT-LC50E LCD projector

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HERE YA ARE! The SERVICEMAN
ALMOST THERE!
KEEP GOING THIS WAY FOR THE SERVICE MAN
TO THE SERVICE MAN
YOU HAVE JUST HIT THE SERVICE MAN'S WHEELY BIN
TO THE SERVICEMAN
EDITH

SHE HAD GOT HORRIBLY LOST AND IT WAS ALL OUR FAULT...

Personally, I feel that all manufacturers should get together for a convention on the OSD language options and colour code, or place them in the same position in all sets. It would make it all so much easier if, for example, English was always in red and Croatian in orange (say) and if the language option was always the fifth item on the menu list. Still, who listens to the technician?

The ticking LG

A dead 1999 LG CA-20F898 (MC-994A chassis) 48cm TV was brought in to be repaired. Nowadays, these sets really aren't worth looking at, considering the price of new ones, but the owner insisted.

Anyway, this set was ticking (pulsating), which meant that the switchmode power supply was in protection mode, probably due to a short circuit.

In a beachside suburb, the usual culprits are the flyback transformer and the line output transistor which would make the cost prohibitive in such a budget model. However, the owner was persistent – he felt sure it could be fixed within his budget and told me to do the best I could.

Well, of course, the line output transistor (Q402, 2SD2499) had gone short circuit so I replaced it, half-expecting it to instantly destruct again at switch-on. Instead, I got a vertical white line down the centre.

This was unusual and is almost always due to a dry joint in the deflection stage – which in a 48cm set is really simple to fix. However, there were no dry joints and the yoke and the horizontal linearity coil were both OK.

That just left yoke coupler C412, a 0.33µF 400V high-current capacitor. Replacing it fixed the problem and the repair came in within budget – a win-win situation for both of us.

Squashing the cockroaches

Edith Montague is in her late seventies and still drives a car – well, barely. One hot summer day she arrived at our place unannounced and her first words to me were that she had got horribly lost and it was all our fault.

We are obviously in the wrong place and all our signs are invisible!

When she finally finished blowing us up for getting lost, I learnt that there was a microwave oven in the back of her car, which Edith repeatedly told me would not give a display. I carried the microwave into the workshop for her and placed it on my bench.

This particular unit was a 1995 Panasonic Dimension 4 Genius Convection Oven, model NN-C855B. I plugged it in and the display came on straightaway. What could she have been thinking? Well, it might be intermittent so I thought I would give it the once over and took the covers off.

As soon as I did this, you could hear the rustle as hundreds of cockroaches ran for cover. I smartly replaced the cover and took it outside where I sprayed a large amount of insecticide inside and beat a hasty retreat. The effect of this poison was pretty rapid and I subsequently blasted the corpses out with an air compressor before carrying the oven back into the workshop.

The cockroaches alone would be easily enough to cause corrosion, in turn giving an intermittent display. However, the problem had to be investigated further, so I removed the front control panel and the PC board. When this was out, I removed a few more jammed corpses and egg sacs before examining the PC board itself. This carried the general mess from a cockroach infestation and there was also some of the infamous brown glue spread over some of the components. And as if that wasn't enough, there were dry joints on pins P and E of the mains transformer (T1).

I also noticed that one of the oven's lamps had failed and so gave her a quote to fix all the above. She wasn't prepared to just take my word for it though and wanted a detailed explanation of all the faults. However, after having a good whinge about the very reasonable estimate I had given her, she finally agreed to the work.

The job was straightforward and when I had finished, I gave it a thorough test to make sure it was working properly. The display was now excellent, especially after a good clean on the outside of the window. I then advised Edith that the oven was ready and she came straight over.

When she eventually arrived, I got another tongue lashing over her getting lost a second time. Now, I can understand someone getting lost once but twice is somewhat careless. After all, we have been at this address for over six years and no-one else had ever got lost.

I wasn't in a position to demonstrate the oven but I assured her that the display had been fixed and that I had tested it. With that, she paid and left, presumably to get lost on the way home. Anyway, I thought that would be the end of the matter but it wasn't to be.

A few hours later, Edith was on the phone, not only complaining vociferously that she still had no display but demanding that I come round immediately and fix it in her home. I was incredulous. How could this be? There had to be another factor. "Are you quite certain there is no display?", I asked. "Absolutely", she insisted.

Perhaps she hadn't plugged the oven in – after all, that would give no display. I asked her if the light came on when she opened the oven door and was told that it did, so scratch that theory.

This had me baffled. As a compromise, I grudgingly said I would call around but explained that I had no facilities to fix anything in her home. If there was a genuine problem, it would have to go back to the workshop.

When I got to her place, I finally understood what she meant by "no display". The display wasn't blank at all but was instead showing just the two little dots which form the colon between the hours and minutes digits. And that to her meant no display.

I switched the unit off and then on again at the power point and the usual "WELCOME" display message immediately came on. However, it would then go into "9 LAMB" and 10 CHICKEN" alternately. Apart from the STOP/RESET button, nothing else worked and I was just left with the time colon. I couldn't even set the clock and it was fairly obvious that the membrane switch was jammed on the 9 Lamb/10 Chicken selection.

Back at the workshop, I removed the membrane switch altogether and it was indeed faulty. Switch Q17 was intermittently short circuit and had probably only previously worked in my workshop because it had been a hot day, which kept the air expanded between the two halves of the membrane switch.

Clearly, the unit would have to be replaced but by now, Edith had lost confidence in both me and her microwave oven. She phoned to inform me she had bought a brand new microwave and asked what part of her money was I going to refund because she "hadn't got anything for it"!

There was really no point arguing but I still wanted to recoup my labour costs for the work I had already done. Anyway, I told her that if she left her microwave behind, I would tear up her cheque.

For some reason, this didn't register with her and she just kept repeating her question over and over again – like a needle stuck in a groove. Eventually, I was forced to put a stop to her tirade. I bluntly told her to stop talking and listen very carefully. What had I said to her?

Well, she couldn't remember. So, very slowly, I repeated myself to her until the message sank in.

She was relieved to get her money back and I got to keep the old oven as compensation for my time and effort. In the end, I replaced the part and then sold it, so I did manage to make some money after all.

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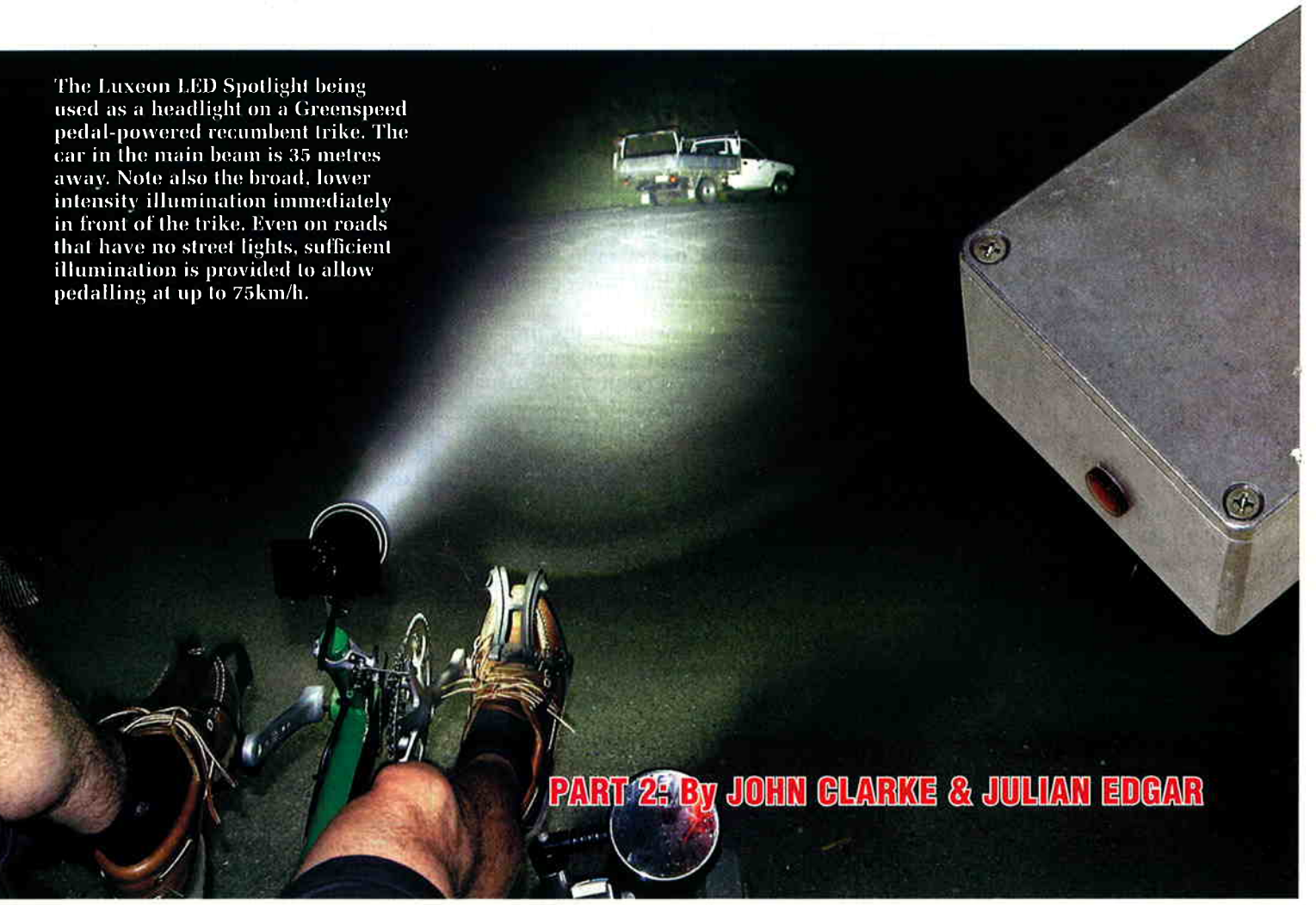
LCD projector

We had a Panasonic LCD projector PT-LC50E come in requiring a new lamp unit (Part No: ET-LAC50 – a mere $600!)

However, after replacing the special globe, the projector intermittently wouldn't work, giving no functions except an error code CØ in the display. This means an incorrectly installed air-filter.

After fiddling around with the unit for a while, we discovered that the cause was due to the door and its sensor switch. However, measuring the plug with an ohmmeter showed there was perfect continuity when the switch was closed.

This was quite baffling until it dawned on us that when measuring the plug, the meter probes were pressing in the pins and making contact. The fault was actually in the plug itself, with the connectors being dry jointed. We just kept missing this with the way we were measuring it. Resoldering them fixed the problem. SC



The Luxeon LED Spotlight being used as a headlight on a Greenspeed pedal-powered recumbent trike. The car in the main beam is 35 metres away. Note also the broad, lower intensity illumination immediately in front of the trike. Even on roads that have no street lights, sufficient illumination is provided to allow pedalling at up to 75km/h.

PART 2: By JOHN CLARKE & JULIAN EDGAR

Universal High-Energy LED Lighting System

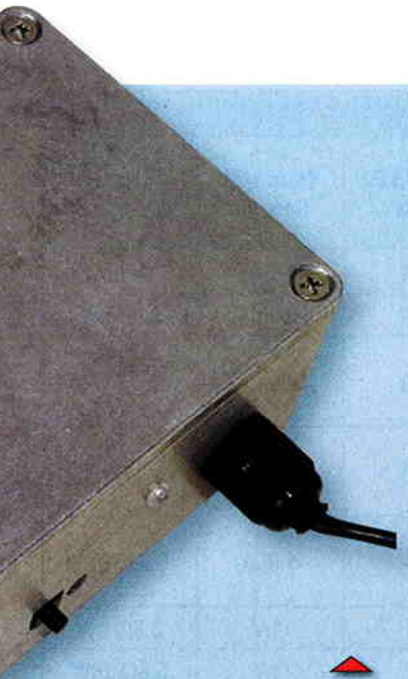
Last month, we introduced our brilliant new Luxeon LED lighting system and described how it works. This month, we look at its construction and describe how to make a very effective Luxeon-powered spotlight.

THE UNIVERSAL High-Energy LED Lighting System is built on a PC board coded 11004061 (104 x 79mm) and is housed in a diecast aluminium box (115 x 90 x 55mm). An aluminium box was used because it provides sufficient heatsinking for Mosfets Q1 & Q2 and for the battery pack (this heatsinking is needed at high charge and discharge rates).

In addition, the aluminium housing is rugged and weatherproof.

Board assembly

Fig.2 shows the parts layout on the PC board. Begin construction by carefully checking the PC board for breaks or shorts between the copper tracks. Repair any defects (rare these days), then install PC stakes at all the external wiring points. Follow these with all the low-profile parts including the wire links, resistors, small capacitors and the diodes.



It might look like a bland box but there's a lot inside! Visible is the cover for the LDR (left) and at right, the on/off pushbutton and the battery status LED. The weatherproof Luxeon output cable can also be seen.

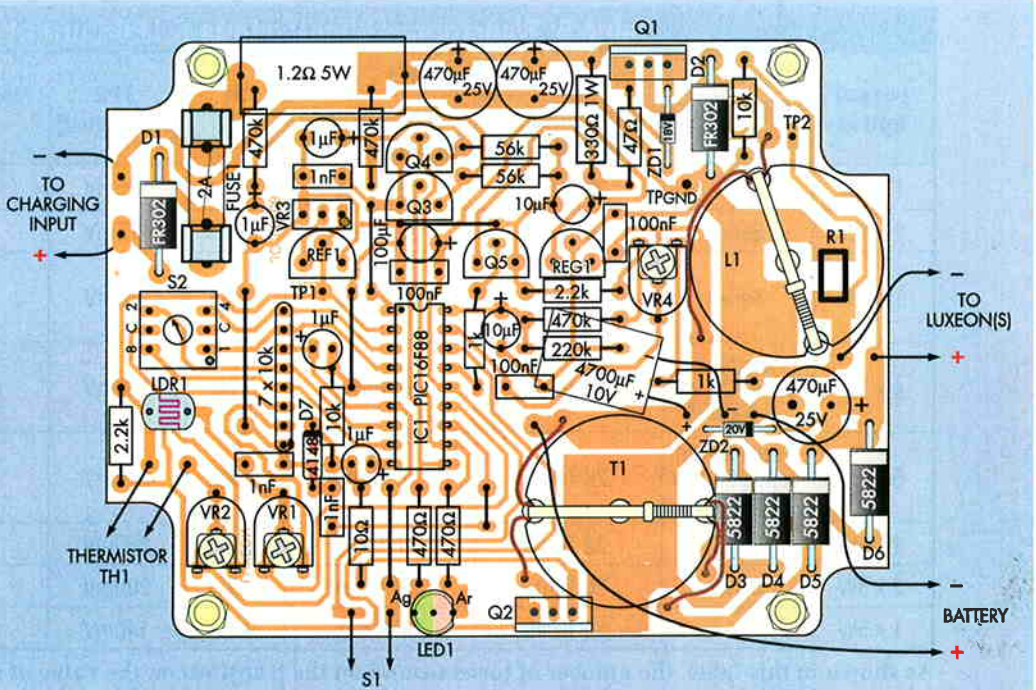


Fig.2: install the parts on the PC board as shown here. Note that R1 is a surface mount resistor and is installed on the copper side of the board. Note also that the 4700µF capacitor is mounted on its side – see photos.

Once these parts are in, you can install the surface-mount resistor (R1) on the copper side of the PC board. You will have to refer to Table 5 to determine which of the two provided surface-mount resistors is installed.

Next, install the electrolytic capacitors, voltage regulator REG1 and the transistors but leave the two Mosfets out for the time being. Make sure that these parts are all correctly orientated (the same goes for the diodes).

Note that the 4700µF capacitor is not mounted vertically – instead, it is positioned on its side (see photo). Be sure to leave sufficient lead length to allow for this positioning.

Winding the inductors

Inductor L1 and transformer T1 can now be wound. L1 simply consists of 38 turns of 0.63mm enamelled copper wire on an FX2240 pot core and bobbin assembly. By contrast, T1's windings depend on the LEDs being driven (see Table 5). It's also easy to make – just wind on the primary turns, then neatly wind on the secondary turns over the top – see Fig.3. The windings can go in either direction.

When winding T1 and L1, use a generous smear of silicone sealant under and over each winding layer. Also smear silicone on the top and bottom of the mating surfaces of each core half. **Note that both L1 and T1 require 0.5mm spacers to separate their pot cores (these can be made**

Table 4: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100n
1nF	.001µF	102	1n0

Table 3: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	56kΩ	green blue orange brown	green blue black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	330Ω 1W	orange orange brown gold	not applicable
❑	1	47Ω	yellow violet black brown	yellow violet black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

Table 5: Transformer Winding Data & LED Current								
Luxeon Option	LED Wiring	Transformer (T1)		R1 2W	TP2 (VR4 adjust)	Individual LED Current	Total LED Current	Test Resistor
		Primary (0.63mm ENCU)	Secondary (0.63mm ENCU)					
1 x 1W		22 Turns	13 Turns	0.5Ω	175mV	350mA	350mA	10Ω 5W
2 x 1W	Series	16 Turns	22 Turns	0.5Ω	175mV	350mA	350mA	22Ω 5W
3 x 1 W	Series	17 Turns	33 Turns	0.5Ω	175mV	350mA	350mA	22Ω 5W & 10Ω 5W in series
4 x 1W	Two lots of series 2 x 1W in parallel	26 Turns	32 Turns	0.2Ω	140mV	350mA	700mA	10Ω 10W
6 x 1W	Three lots of series 2 x 1W in parallel	26 Turns	36 Turns	0.2Ω	210mV	350mA	1.05A	6.8Ω 10W
1 x 3W		22 Turns	17 Turns	0.2Ω	200mV	1A	1A	3.3Ω 5W
2 x 3W	Series	26 Turns	36 Turns	0.2Ω	200mV	1A	1A	6.8Ω 10W
1 x 5W		26 Turns	36 Turns	0.2Ω	140mV	700mA	700mA	10Ω 10W

As shown in this table, the number of turns wound on the transformer, the value of resistor R1 and the adjustment of trimpot VR4 all depend on the LEDs that are to be driven. In addition, this table shows whether the LEDs are wired in series, parallel or a series/parallel combination. Note: there is no option to use five 1W LEDs.

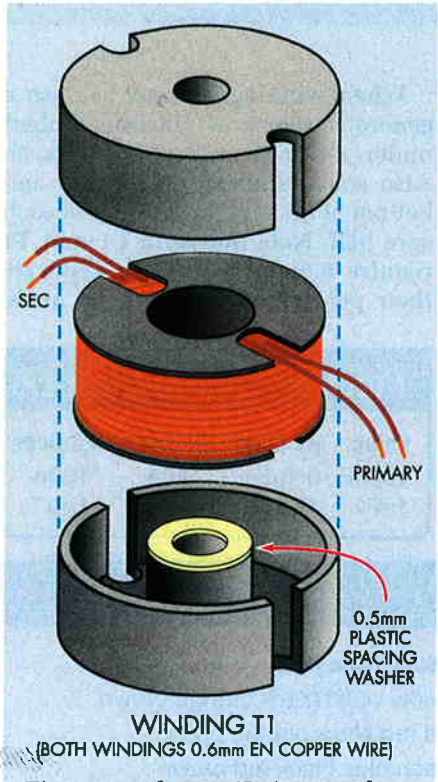


Fig.3: transformer T1 is wound using 0.63mm enamelled copper wire – see Table 5. The windings can be made in either direction. To reduce noise, the windings should be sealed with silicone, as described in the main text. Note that a 0.5mm spacer is inserted in the middle of the cores for both T1 and inductor L1.

from 0.5mm plastic sheet). These spacers sit between the central bosses of the pot cores.

The final step in the construction of these components is to force silicone into the gaps on the outside of the cores. Clean up the edges with a sharp knife when the silicone has set.

Important: if you do not use sufficient silicone, the inductor and transformer will emit buzzes and squeals – so use plenty of it!

Having completed winding the inductors, they can be installed on the PC board. Be sure to orientate T1 so that its secondary winding goes to the right, so that the leads connect to the bridge rectifier (D3-D6).

Other parts

Switch S1, the battery charge/discharge LED (LED1) and the LDR can

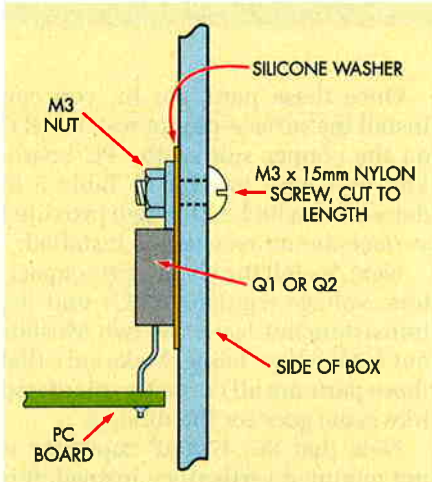


Fig.4: Mosfets Q1 & Q2 must be insulated from the metal case using insulating washers and Nylon screws, as shown here. Note that the Nylon screws should be cut to length.

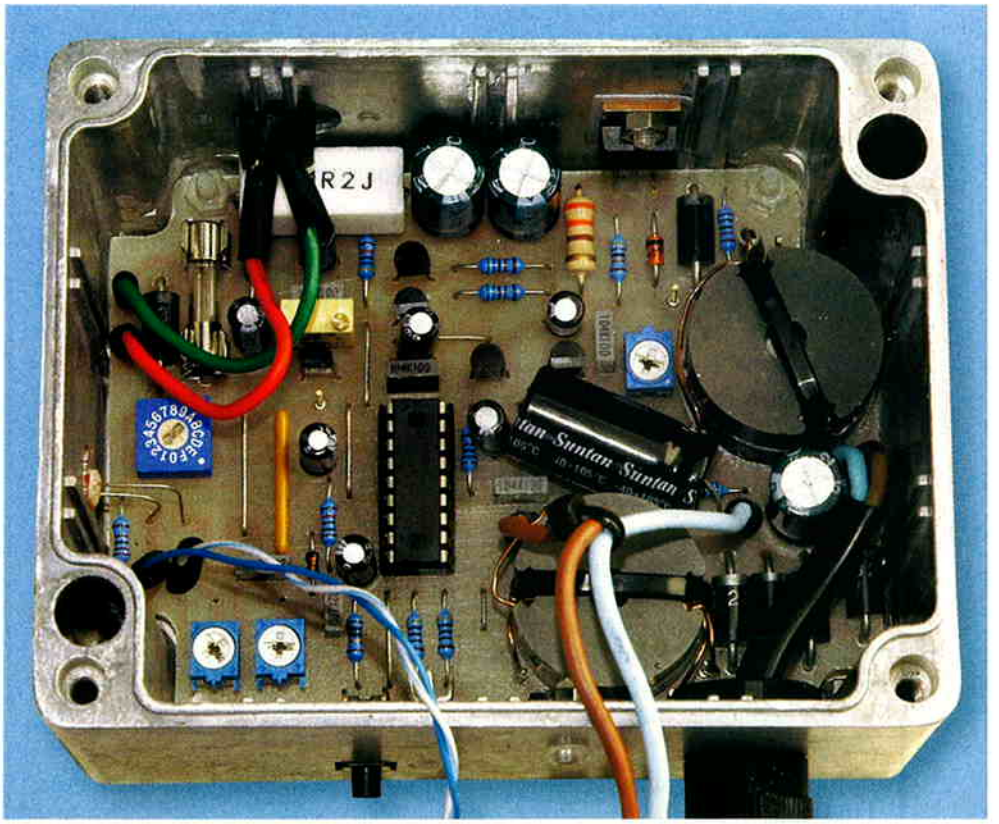
Changing the PWM Frequency

During normal operation, a faint "squeal" is emitted from the electronic circuitry or more specifically, from the transformer. This can be quietened if a higher (13kHz) PWM frequency is selected, rather than the default 7.8kHz.

The downside is that the dimming functions will not work as precisely. To change the frequency, first select position 14 (E) on the BCD switch. That done, wait for the red LED to come on and then turn off, then select another switch position. The frequency will change from 7.8kHz to 13kHz, which is virtually inaudible in this application.

If you select position E again, the PWM frequency will revert to 7.8kHz.

To provide clearance, the stand-offs within the box must be removed. This can be done by using a large-diameter drill bit followed by a high-speed de-burring tool or a grinding stone held in the chuck of an electric drill.



The electronics are a tight fit in the box, with one capacitor being placed on its side. Be sure to wind the inductors tightly, to minimise audible high-frequency noise from them.

now all go in. In each case, leave sufficient lead length to allow these components to be bent back out of the way when fitting the PC board into the box. The LED must be mounted with its leads bent at right angles, so that it can later be pushed through a matching hole in the side of the case.

Before the PC board can be fitted into the box, the integral stand-offs need to be removed. This can be achieved using a large diameter drill, followed by a high-speed deburring tool or a grinding stone held in the chuck of an electric drill. Wear safety goggles when performing this job.

Once the standoffs have been removed, position the board inside the case and mark out and drill the four corner mounting holes. These holes should be countersunk, so that the heads of the Nylon mounting screws sit flush with the lower surface of the box. That done, temporarily secure the board in position using 4mm-long Nylon spacers and 3M x 12mm Nylon screws and nuts – see Fig.5.

Note: the four 4mm-long Nylon spacers are made by cutting two 9mm spacers in half.

Mounting the Mosfets

The next step is to determine where the mounting holes go in the case for the two Mosfets. To do this, first crank their leads slightly as shown in Fig.4, then slip them into their board mounting holes. Next, push the two Mosfets down into their holes until they are about 12mm proud of the board and position them so that their metal tabs sit flat against the case.

You can now mark out their tab mounting holes from inside the case. Once that's done, remove the PC board (and the Mosfets), transfer the hole locations to the outside of the case and drill them to 3mm. These two holes

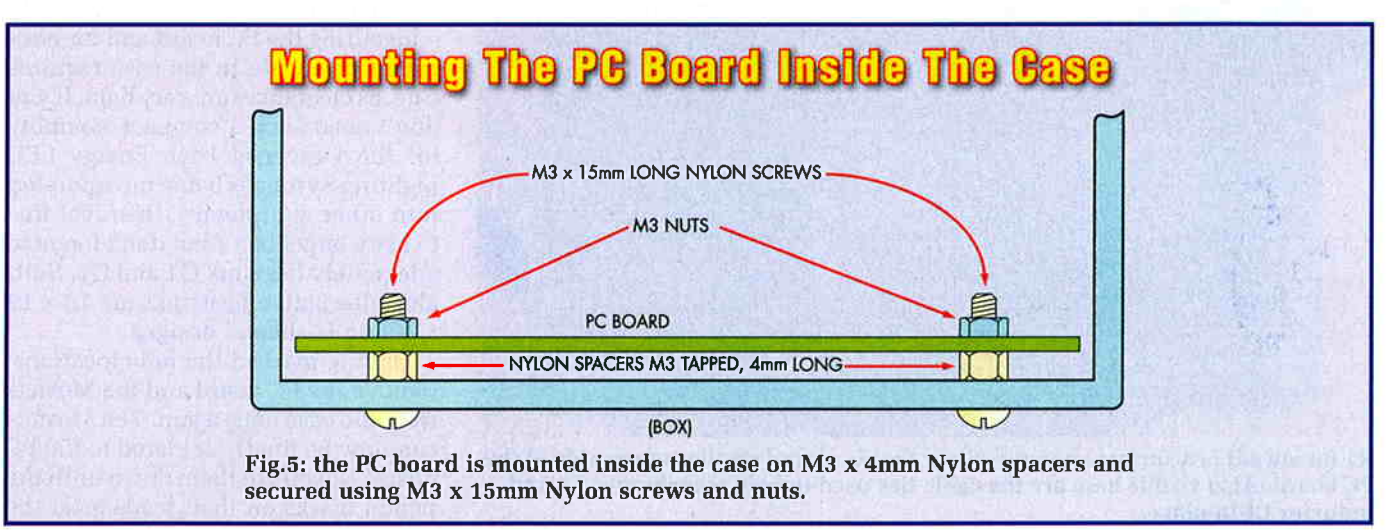


Fig.5: the PC board is mounted inside the case on M3 x 4mm Nylon spacers and secured using M3 x 15mm Nylon screws and nuts.

Adjusting The Charging Current

In its default condition, the Universal High Energy LED Lighting System is designed to be used with a power source that can recharge the batteries at up to 700mA. Note that because of the temperature rise that occurs primarily in the batteries, this is the maximum recommended continuous charge rate.

However, there are some applications where better results can be gained by altering this charge rate. For example, if you're using a solar cell, you may have a maximum charging current capability of only 300mA available. On the other hand, if you're using a human-powered generator that can develop discontinuous bursts of 1A, you may want to charge at this higher rate.

As a result, the charging current can be set anywhere from 100mA to 1A in 50mA increments.

Note that the charging current referred to here is the current delivered to the Universal High Energy LED Lighting System, not the current supplied to the battery.

The current supplied to the batteries is dependent on both the input voltage and the charging voltage. At input voltages between about 8.6-12.6V, the battery charging current is similar to the input current. Above 12.6V, however, the battery charging current increases with input voltage. For example, at 18V input, the battery is charged at about twice the current that is supplied to the input. This is possible because the charging circuit is a power converter – it converts the high input voltage into a lower voltage to correctly charge the battery and at the same time, increases the battery charging current.

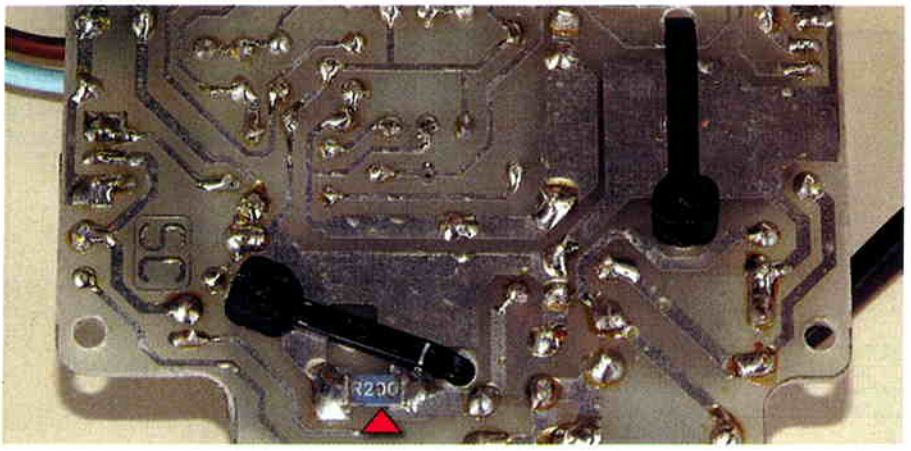
To change the charging current from its default value of 700mA, just follow these two steps:

(1) Set the BCD switch to Mode 15 – marked as 'F' on the switch. The green indicator LED will then flash at a 1-second rate, to show the charging current that has been set. Each flash equals 50mA and there is a 2-second break between each flash group. For example, at the default 700mA charge rate, the LED with flash 14 times, then there will be a 2-second delay, then it will flash 14 times again, and so on.

(2) To alter the charge current, press the pushbutton switch and hold it down, counting the number of flashes. Let the pushbutton go when the required current value has been reached. The LED will acknowledge the new setting with a revised flash number.

Note that if the BCD switch is changed while the current reading is being flashed, the LED will continue to flash the code until it finishes its sequence.

Note also that plugpacks are not generally used at their full rating. This means that if you have (say) a 700mA-rated plugpack and you set the charging current to 700mA, you can expect the plugpack to become quite warm.



R1 (arrowed) is a surface-mount resistor that is placed on the copper side of the PC board. Also visible here are the cable ties used to hold transformer T1 and inductor L1 in place.

Adjustments & Test Points

VR1 – sensitivity of the Light Dependent Resistor

VR2 – sensitivity of the thermistor

VR3 – reference voltage

VR4 – Luxeon LED current

S1 – operator's pushbutton

S2 – Mode BCD rotary switch

TP1 – test point for setting reference voltage

TP2, TP GND – test points for measuring voltage across R1 to set LED current

must then be carefully deburred using an oversize drill so that the inside surfaces are smooth and free of any metal swarf which could later puncture one of the insulating washers.

The next step is to remount the PC board inside the case, after which the two Mosfets are mounted in position. Bolt them to the side of the case using M3 screws, then use a sharp pencil (or a fine-tipped pen) to mark where their leads meet the PC board.

Before removing the board again, you also need to mark out the hole locations for the cable gland, the pushbutton switch, the indicator LED and the charging socket. Similarly, if the LDR is not going to be mounted remotely, a hole also needs to be made for this component (this can go in the lid or in the side of the case).

The accompanying photos show the locations of the various holes. Be sure to position these holes accurately – installing the PC board and its associated hardware in the case requires care, as clearances are very tight. If you don't need such a compact assembly (or the Universal High Energy LED Lighting System is being incorporated into other equipment), then feel free to use a larger box – but don't forget to adequately heatsink Q1 and Q2. Suitable alternative heatsinks are 19 x 19 x 10mm U-shaped designs.

Having marked the hole locations, remove the PC board and the Mosfets from the case once again. The Mosfets can now be finally soldered to the PC board – just push them down until the pencil marks on their leads meet the

board surface, then carefully solder these leads to their respective pads.

Now drill the holes in the case for the other parts. The square cutout for switch S1 is best made by drilling a hole that's smaller than the finished size and then filing to the required rounded rectangular shape.

Once that's been done, the PC board can be finally mounted in place (see Fig.5) and the two Mosfets (Q1 & Q2) secured to the side of the case. Fig.4 shows the mounting details for the Mosfets. Note that they must be electrically isolated from the metal case. This is achieved by using a silicone washer and by using M3 x 15mm Nylon screws and nuts to fasten them in position.

Having secured them, switch your multimeter to a low "ohms" range and check that the device tabs are indeed correctly isolated from the metal case.

The switch, indicator LED and the LDR can now be pushed through their respective holes and secured in place with silicone sealant.

The cells, main fuseholder and thermistor are glued to the inside of the lid using silicone sealant – see Fig.6. Note the location of the thermistor – it should be placed in the centre of the battery pack.

Make sure that the cells sit hard against the lid and leave plenty of time for the sealant to fully cure before moving the assembly. We used C cells that did not come with solder tags but since soldering directly to NiMH cells is not recommended, we suggest you use cells with tags. Use 7.5A wire for the batteries, 5A wire for charger leads and twisted pair light-duty hookup wire for the NTC thermistor.

A few precautions

Before moving on to the setting-up procedure, there are a couple of precautions you need to observe. First, always make sure that the power is off when working on the circuit. This can be done by removing the main battery fuse.

Second, after the circuit has been running, the 4700µF capacitor must be discharged. To do this, press the switch twice in modes 1, 2 or 3 to momentarily light the Luxeon LEDs.

Incidentally, transformer T1 becomes hot when powering a full Luxeon load and at high charge rates, the batteries also become quite warm.

Setting up

Make sure that the battery pack is connected with the correct polarity, then install the fuse. You now need to go through the following setting-up procedure:

(1). IC1 power check: Set S1 (the BCD Mode switch) to F, then use a multimeter to check that there is battery voltage between pins 5 & 14 of IC1. If there is sufficient charge in the battery pack, this voltage will be 5V.

(2). Adjust the reference voltage: con-

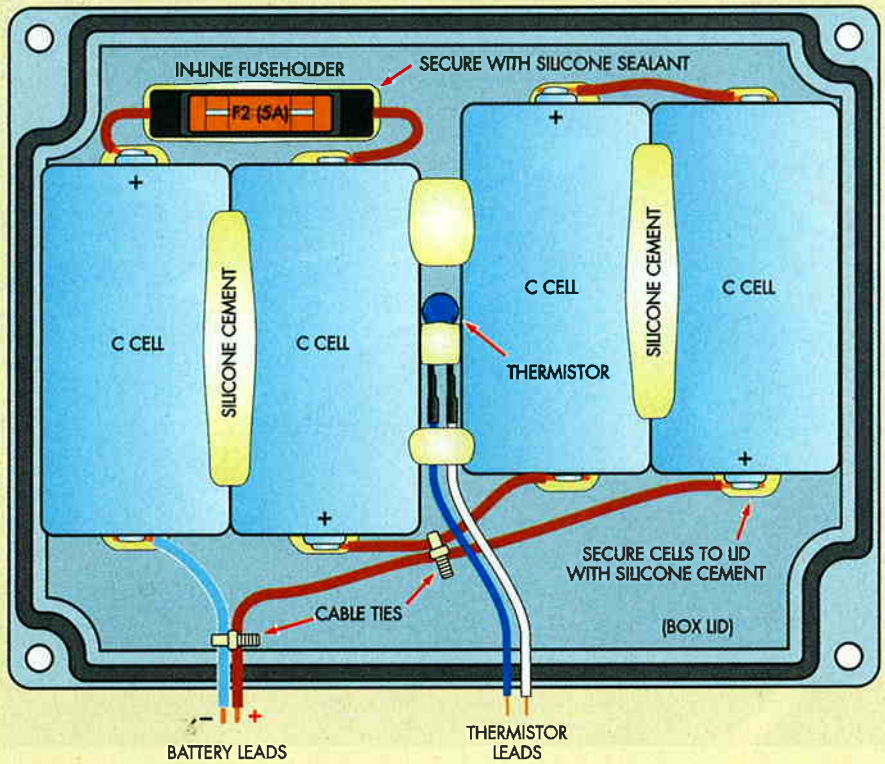


Fig.6: the four 4500mAh cells, the fuseholder and the thermistor are glued to the lid using silicone sealant. They must be wired as shown here.

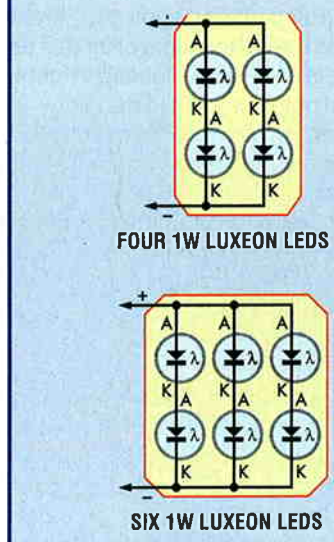


Fig.7: in most cases, wiring the Luxeon LEDs is straightforward. However, when running four 1W or six 1W Luxeons, series/parallel arrangements must be used, as shown here.

Matching The Light From Multiple Luxeons

If the Luxeons are wired with parallel connections, it is best to match the devices so they each have a similar brightness. Devices with exactly the same type number printed on the back are generally the same in terms of voltage drop at the rated current.

If you find that one or more Luxeons in a series/parallel connection is dimmer than the rest, it is not well matched with the others. In that case, reduce the drive current using VR4, so that the brighter LEDs are not over-driven.

This version of the spotlight differs a little from the one described in the text in that aluminium – rather than U-PVC plastic – has been used to form the front rim. The aluminium rim was machined from the base of an old BCF aluminium fire extinguisher. When there's usually plenty of airflow, the heatsink shown on this light is effective with a 5W Luxeon LED. In non-ventilated applications, a larger heatsink should be used.

Making a LED-Powered Spotlight – use it as a bicycle headlight

Here's how to build a durable and effective LED-powered spotlight – great for use as a bike headlight or for use as hand-held long-range lighting system. The light output is just outstanding – in fact, when you consider its miserly 5W power consumption, it's nothing short of fantastic.

Apart from the electronic control you only need a handful of parts. The accompanying parts list shows what you need.

Building it

OK, let's build it. First, cut a hole about 65mm in diameter in the centre of the plastic plumbing cap. Sand the edges smooth and then use silicone to glue the lens within the cap. This assembly forms the focusing lens.

Next, drill holes in the heatsink to allow small nuts and screws to be used to attach the LED to the heatsink. Drill an additional pair of holes in the heatsink to allow the power supply wiring to the LED to pass through the heatsink. Alternatively, these wires can pass through a hole drilled in the stainless steel drinking cup.

Now use a file to shorten the plastic legs of the collimating lens so that it sits squarely over the LED, legs resting against the heatsink and the centre of the collimator in contact with the LED. Place some heatsink compound under the LED and then attach it to the heatsink using the small screws and nuts. Check that the heads of the screws do not short the power supply connections to the LED (you may want to use Nylon nuts and bolts).

Once the LED is in place, glue the collimating lens securely in place. That done, pass the wiring through the heatsink and solder it to the LED, then seal the holes through the heatsink with silicone.

The next step is to cut a 35mm hole in the centre of the bottom of the stainless steel cup. If the spotlight is to be permanently mounted, drill the cup for any brackets that will be needed. Deburr all holes, then position the heatsink on the bottom of the cup so that the LED and collimator lens project through the 35mm hole.

Finally, mark and drill the holes to bolt the heatsink to the cup, sealing this join with silicone.

Testing

Test the operation of the LED with the focusing lens in place. The assembly should throw a *very* bright spot of light about 600mm wide on a wall three metres away. This beam angle is ideal for a long-range bike headlight, or for a general-purpose spotlight or high-powered torch.

If all is working satisfactorily, use silicone to glue the lens assembly in place.

Performance

The performance of the prototype

Parts List

1 5W Luxeon LED
1 narrow-beam collimating lens (eg, Jaycar ZD-0420)
1 large finned heatsink to suit the LED – eg, Altronics Cat. H0520 or an ex-PC processor heatsink
1 stainless-steel drinking cup
1 U-PVC plastic plumbing cap that fits over the open end of the cup
1 magnifying glass (glass – not plastic!) the same diameter as the open end of the cup
Assorted small nuts and bolts

Note: in most cases, the cup mouth will have a diameter of 75mm, making it easy to source the plastic cap and magnifying glass.

unit – which is used as a bike headlight – was outstanding. On a country road lacking any street lights, and tested on a very dark night with no moonlight or starlight, sufficient illumination was provided by the headlight to allow for safe pedalling downhill at over 75km/h. Used as a handheld spotlight, it could easily illuminate trees 50 metres away.

If less power is required, a 3W LED can be used in place of the 5W LED. If the assembly is always going to have airflow over it (eg, if it is being used as a bike headlight), the 3W LED can be bolted to the inside of a single-wall cup and the cup itself used as the heatsink. This saves having to make the large hole in the bottom of the cup and removes the need for a separate, finned heatsink. A stationary 3W light should retain the finned external heatsink.

If you want the best, though, the 5W design described above is it! But if you simply want a compact but still very effective spotlight beam, the 3W Luxeon with the Jaycar narrow beam collimator (Cat. ZD-0420) gives excellent results.

Finally, single-wall stainless steel drinking cups can now be very hard to find but Coastal Kitchen and Cutlery on the Gold Coast (07 5526 9399) have them in stock at $5.50 each. A double-wall (ie, insulated) cup can also be used but it is heavier and more difficult to drill.

Making A Low-Cost 1W Luxeon LED Housing

Here's how to make a durable and good-looking weatherproof housing for a 1W Luxeon LED when it's used with either Jaycar ZD-0420 or ZD-0422 collimators.

You'll need a PVC 25mm Class 18 pipe cap (about $3 from a hardware store), some black silicone and a few hand tools.

Start by using a file and sandpaper to smooth away the raised writing to be found on the back of the cap (this doesn't do anything for the engineering but a lot for the aesthetics!). That done, drill a hole for the cable entry and also any other holes needed for mounting brackets. If used, the brackets should be attached at this point. And if you intend painting the housing and bracket, do it now.

Next, solder the wires to the LED, feed them through the hole in the housing and position the LED at the bottom. Secure it in place with some silicone, then shorten the legs on the collimator so that it sits over the top of the LED. Carefully apply silicone around the upper part of the collimator, ensuring that you seal the gaps.

You can now slide the collimator into place in the housing, making sure that it engages with the LED. Use a rag to carefully wipe away the surplus silicone but be sure to fill any gaps around the edge of the LED. Finally, place a little silicone around the cable exit to seal this opening.

Note that because there is no provision for heatsinking, this housing is not suitable for 3W and 5W LEDs.

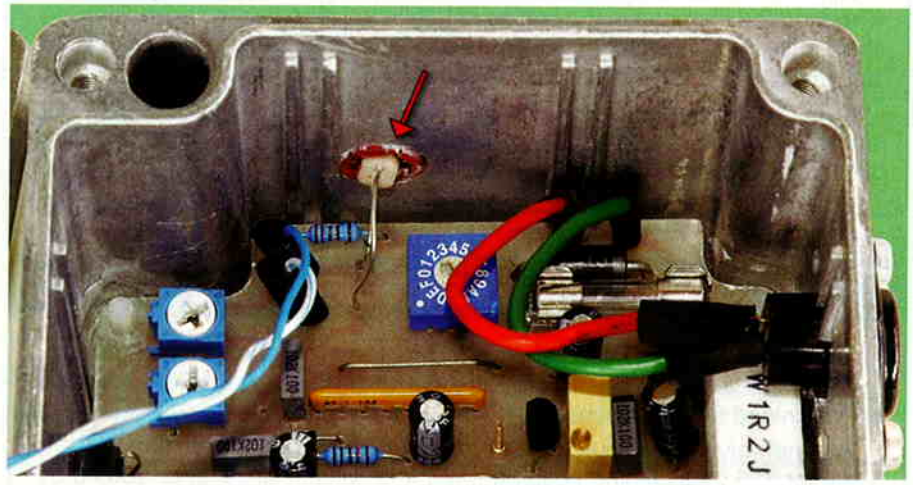
nect a multimeter between the negative battery lead and TP1. Adjust VR3 for 2.490V.

(3). Thermistor calibration: adjust trimpot VR2 so that there's 1.25V across the thermistor terminals at 25°C.

(4). Connect the test resistor: wire a test resistor across the Luxeon LED output (ie, in place of the Luxeon LEDs). Table 5 shows the value to use. Also, use Table 5 to check that both R1 and T1 are correct.

(5). Setting the LED current: set VR4 fully anticlockwise and set S2 to Mode 1. Switch on the system by quickly pressing S1 twice. Measure the voltage between TP GND and TP2. Set the correct voltage using VR4, according to Table 5. **Note: during this process, the test resistor will get very hot.**

(6). Connecting the LEDs: wire in the Luxeon(s), making sure their polarity is correct and **ensuring the Luxeons are adequately heatsinked!** Again



The multi-position BCD switch (centre) sets the operating mode of the system. Also visible is the Light Dependent Resistor (arrowed) that's used in some modes to automatically switch on the Luxeon LED as ambient light changes. Depending on requirements, this LDR (arrowed) can either be mounted within the box (and sensing the light through a cut-down neon bezel) or mounted remotely.

Be Sure To Provide Adequate Heatsinking

Heatsinks must be used with both 3W and 5W Luxeon LEDs. Even the 1W LEDs, which normally don't require additional heatsinking, can do with some additional heatsinking when run continuously at full power in hot conditions.

In all cases, keeping the LED junction temperature low will give greater light output and longer LED life.

The size of the required heatsink depends on:

- the nominal power of the LED;
- whether it is run at maximum current;
- whether it is on continuously or is flashed (and if flashed, the duty cycle);
- the ambient temperature;
- ventilation; and
- the thermal resistance of the heatsink.

ABOVE: a processor heatsink salvaged from an old PC is ideal for cooling 3W & 5W Luxeon LEDs. Remove the old heat transfer pad in the centre using solvent, before attaching the LED.

If there is plenty of space available, it pays to simply run the best heatsinking possible. In all cases, care must be taken to ensure that the aluminium face of the PC board used for the LED is thermally connected to the heatsink. The heatsink must be absolutely flat (no burrs from drilled holes) and a smear of heatsink compound should be placed between the LED's PC board and the heatsink. In addition, the LED should be held in place securely with nuts and bolts.

Ex-PC processor heatsinks are excellent for Luxeon LEDs, with older 486-sized heatsinks suiting 3W LEDs and larger heatsinks from later model PCs suiting the 5W LEDs. If ventilation is poor, the fan that's often found attached to these heatsinks should be retained.

If the LED drive voltage is nominally 6.8V (as it is when running a single 5W LED or two series 3W LEDs), the fan can be wired directly across the Luxeon output. It will rotate more slowly than if fed from 12V but it will still spin fast enough to greatly improve heatsink performance.

Note that the current should be increased to take into account the fan draw. The required increase in the setting of VR4 can be calculated by multiplying the fan current in amps at 6.8V by the value of R1, which in these LED applications is 0.2Ω. Typically, it's about a 15mV increase.

In short, be generous with the heatsinking and if the heatsink gets hot during operation, consider using a larger unit. Alternatively, consider adding a fan if you haven't already done so.

Where To Buy Programmed PICs

For those capable of doing their own programming, the software (luxeon.hex) for the PIC16F88-E/P microcontroller used in this project will be available for download from our website.

Alternatively, you can purchase a programmed microcontroller from SILICON CHIP for $25.00 including postage anywhere within Australia, or $30.00 by airmail elsewhere.

Note: it's unlikely that a complete kit of parts will be offered for this project. However, you should have little difficulty buying the parts separately from parts retailers. The PC board can be purchased from RCS Radio.

measure the voltage between TP GND and TP2 and make the final adjustments using VR4 and Table 5.

The reason that the test resistor is initially used in place of the Luxeon LED is for safety. If you have made a major mistake that results in uncontrolled current at the output, the resistor will simply get a bit hotter. And that's much better than blowing an expensive LED – something that can happen in the blink of an eye.

As mentioned last month, when the system is switched off, it's normal for the battery monitor LED to flash momentarily every second or so.

Wiring the supply plug

If you're using a plugpack and/or car cigarette lighter plug to charge the Universal High Energy LED Lighting System, you'll need to wire a 2-pin DIN plug to the power source.

In the case of a plugpack, cut off the original DC plug and separate and bare the ends of the cable. Slip the DIN plug cover over the cable, then use a multimeter to determine the polarity of the plugpack output. Solder the positive lead to the smaller of the two DIN plug pins and the negative to the larger pin.

Make sure that the connections cannot touch one another – you may want to use some electrical tape or heatshrink around the soldered connections.

Finally, slip the DIN plug cover back over the plug and use a multimeter to confirm that the voltage polarity is correct.

The procedure is similar for a cigarette lighter plug. In this case, you have to connect a 5A (minimum) figure-8 cable between the lighter plug and the DIN plug (don't forget to first slip the cigarette lighter plug and DIN plug covers over the cable).

Connect the smallest DIN plug pin to the tip of the cigarette lighter plug. The larger DIN plug pin then goes to the side (chassis) connection of the cigarette lighter plug.

Conclusion

Despite its unassuming appearance, the Universal High Energy LED Lighting System required a major investment in time and effort. The result is a LED lighting system that's unmatched in flexibility and application. **SC**

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Just some of the uses . . .

- Connecting unbalanced signals to balanced Public Address Amplifier inputs and mixers.
- Ideal for connecting to powered instruments.
- (Not suited for high-impedance guitar pickups unless via a preamp or effects unit, etc.)

Hum and noise plaguing your performance? Longing for a DI Box that performs as well as a powered unit but does not require batteries? Here it is:

SILICON CHIP Passive DI Box

by JOHN CLARKE

Musicians and performers often have to connect to an existing PA system in a pub or club, hall, auditorium, church, etc.

You might think that's as simple as plugging a lead from the output socket of an instrument, effects unit, preamp, etc into an appropriate input on the PA system. But it's not usually quite that simple.

For a start, most musical equipment has 6.35mm phono jacks, while most "pro" mixers and amplifiers use XLR connectors. Even if the incompatible leads problem can be solved (why is it that your lead always has male plugs and their equipment has male sockets?), even using a special interconnecting lead, there is usually a far greater problem.

Hummmmmmmmmmmm . . . . .

There will sometimes, even often, be a large amount of mains hum and noise introduced into the long leads generally associated with these installations.

So by the time the signal reaches the mixer, which is the heart of a typical Public Address System, hum and noise will mar the performance.

If you're lucky, it's barely tolerable; usually it's not!

That's where the DI Box comes in. Just in case you were wondering, the term DI stands for Direct Injection and refers to the direct coupling-by-wire of a musical instrument to a sound system rather than using a microphone to pickup the sounds.

Apart from converting from the 6.35mm jack connection to the XLR type, the DI Box produces a balanced signal output. The balanced signal is then applied to the balanced input of the audio mixer. Balanced signal lines can greatly reduce injected hum and noise.

The balanced signal cable has two signal lines and a ground return. Pins 2 and 3 of the XLR connector carry the signal and pin 1 is the ground.

The signal lines operate in antiphase to one another so that as one line goes positive, the other line swings negative. At the mixing end, the balanced signal is applied to a differential amplifier which amplifies the "difference" between the two signal lines. This process means that any hum and noise picked up along the balanced lines is effectively cancelled.

One final feature of the DI Box allows isolating the grounds of the musical instrument and the Public Address system. As every hifi buff knows, all equipment needs to be earthed back to the same point. Otherwise circulating currents can occur in the earth system and large amounts of hum can be introduced to the system.

For safety's sake, both the PA system amplifier and the instrument need to be grounded (or earthed – it means the same thing) – but these grounds can be many (sometimes many, many!) metres apart: a classic recipe for hum.

It's called a hum loop – and fortunately can be easily remedied by lifting or breaking the two earth connections.

A DI Box generally does this with a switch that opens or closes the earth connection. Some DI Boxes have a separate ground lift input instead of the switch. In most cases, the DI box can be used with the ground lift switch open or closed.

The SILICON CHIP Passive DI Box provides all the above features. However, it does not provide for all DI applications – for instance, it cannot be used directly with a guitar. Many DI Boxes provide high input impedance so that the unit will not load down and degrade the signal source from a guitar pickup.

Features . . .

- No power required
- Small size
- Rugged housing
- Balanced XLR output
- Unbalanced "thru" output (stereo or mono)
- Stereo input mixing for mono out
- Wide frequency response
- Ground lift switching

In order to provide this high input impedance, a DI Box generally requires electronic circuitry to perform the impedance transformation and to drive the balanced lines. These DI Boxes require power by way of a battery, plugpack or phantom power from the mixer.

Our new DI Box is not powered. It uses a transformer to provide the balanced output and the input impedance is not high enough for a guitar pickup on its own. Of course, it can be used with a guitar if you use a preamplifier or suitable effects box ahead of the DI Box. These units will provide the drive required.

Otherwise, for stand-alone guitar use, we recommend the powered DI Box published in the August 2001 issue of SILICON CHIP.

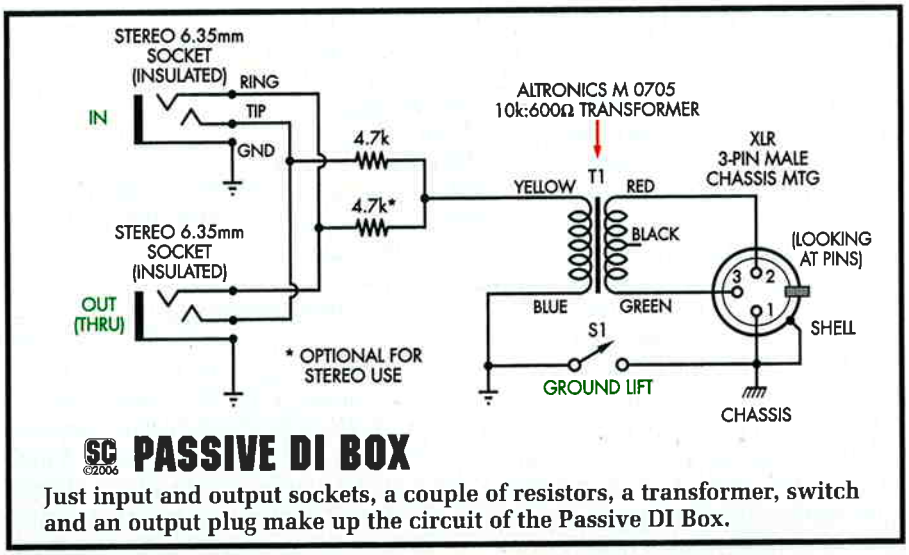
The Passive DI Box can be driven from any source that is capable of driving a 9.4kΩ load at up to 1V rms. This would include virtually any output from keyboards, preamps and effects units, mixers, etc.

Speaking of mixers, the Passive DI Box has its own stereo mixing feature. If you insert a stereo jack with stereo signals, the DI Box will mix the two channels before providing a balanced mono output. This feature is ideal for connecting stereo sources, such as from audio-visual equipment and multimedia players.

Note that the signal produced through the PA system will be mono. To provide a stereo sound, you'll need two DI Boxes, one for the left channel and one for the right channel .

Performance

Performance of the SILICON CHIP Passive DI Box is exceptional. During tests, it far outperformed one com-



SC PASSIVE DI BOX

Just input and output sockets, a couple of resistors, a transformer, switch and an output plug make up the circuit of the Passive DI Box.

monly available commercial unit we were using for comparison, in terms of audio sound quality and frequency response.

In fact, our tests for signal-to-noise ratio do not do the unit justice. The tests results are below the noise floor of our equipment.

While the frequency response of the commercial unit was very restricted in the bass region (reducing signal by -3dB at 250Hz, -6dB at 125Hz and more than -12dB at 60Hz), our unit could pass signals well below 20Hz without any appreciable attenuation. Musicians who have played with our Di Box also remarked that it had a higher quality sound than the commercial unit.

So you'd be much better off building the SILICON CHIP Passive DI Box than buying some commercial units at many, many times the price.

If you must buy a DI box (for example, to use with a guitar), be sure that the specifications are suitable for your application.

In most cases, the 12dB reduction in signal at 60Hz for the commercial unit would not be satisfactory unless the response is tailored with an equaliser. But why lose frequency response in the first place?

Having said that, many higher quality commercial DI boxes *do* use a professional audio transformer that has a wide frequency response. So shop around and read the specs!

The circuit

The exceptional sound quality from the Passive DI Box is because the circuit is based around a high-quality audio transformer from Altronics.

Designated the M 0705, this particular transformer has a 10kΩ winding and a 600Ω centre-tapped winding that makes it ideal for our DI Box design. The transformer also uses a Mu-metal shield to prevent hum fields entering the windings. Two stereo 6.35mm jack sockets connect in parallel. Ordinarily, one is for the input signal while the second provide a "thru" output for daisy chaining the signal to another input. This "thru" output can be connected to an amplifier.

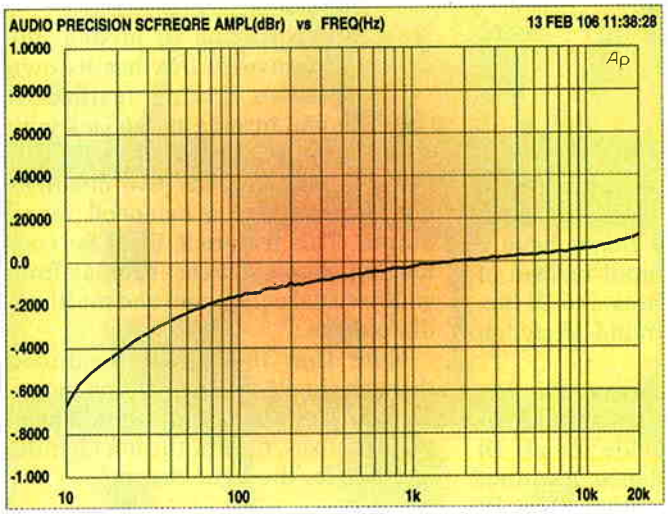
As we mentioned, the DI box will also mix a stereo signal to mono. The tip and ring connections on the socket are coupled using 4.7kΩ resistors for this purpose. The resistor for the ring output also prevents the possibility of the signal from a stereo source being shorted to ground. This could otherwise happen if a mono jack plug is inserted into the "thru" socket.

The resulting signal is applied to the 10kΩ primary winding of T1. The input socket grounds connect to the ground end of this winding.

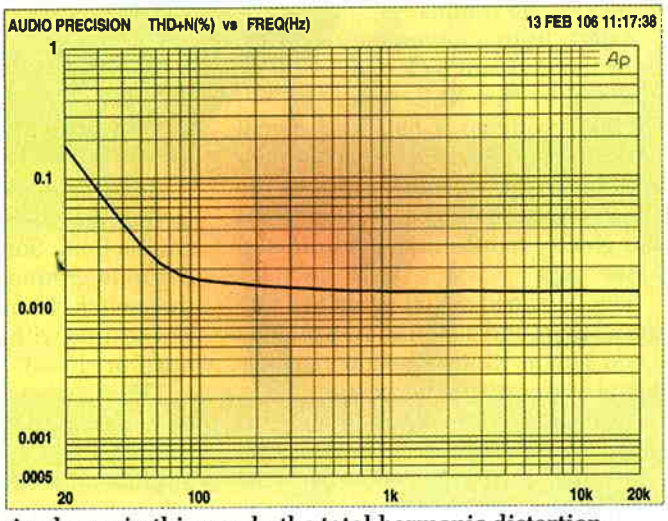
The 600Ω secondary of T1 becomes the balanced output, with pins 2 and 3 of the XLR plug connecting directly to this winding. The centre tap of the secondary winding is not used.

Pin 1 of the XLR is the ground pin and is connected to the shield (shell) of the plug housing. This provides shielding for the XLR plug when it is inserted into this socket.

The common ground connection between the input ground and the pin



While the frequency response of the Passive DI Box may not appear flat in this graph, take a look at the vertical scale. The full scale vertical axis is only 1dB above and below the central 0dB level! The DI Box response is within 0.5dB from 20Hz to 20kHz when driven with a 50Ω source.



As shown in this graph, the total harmonic distortion (THD) for the Passive DI Box is less than 0.02% over the frequency range from 80Hz to 20kHz when supplied with a 1V RMS signal. The distortion is even lower with less input signal level.

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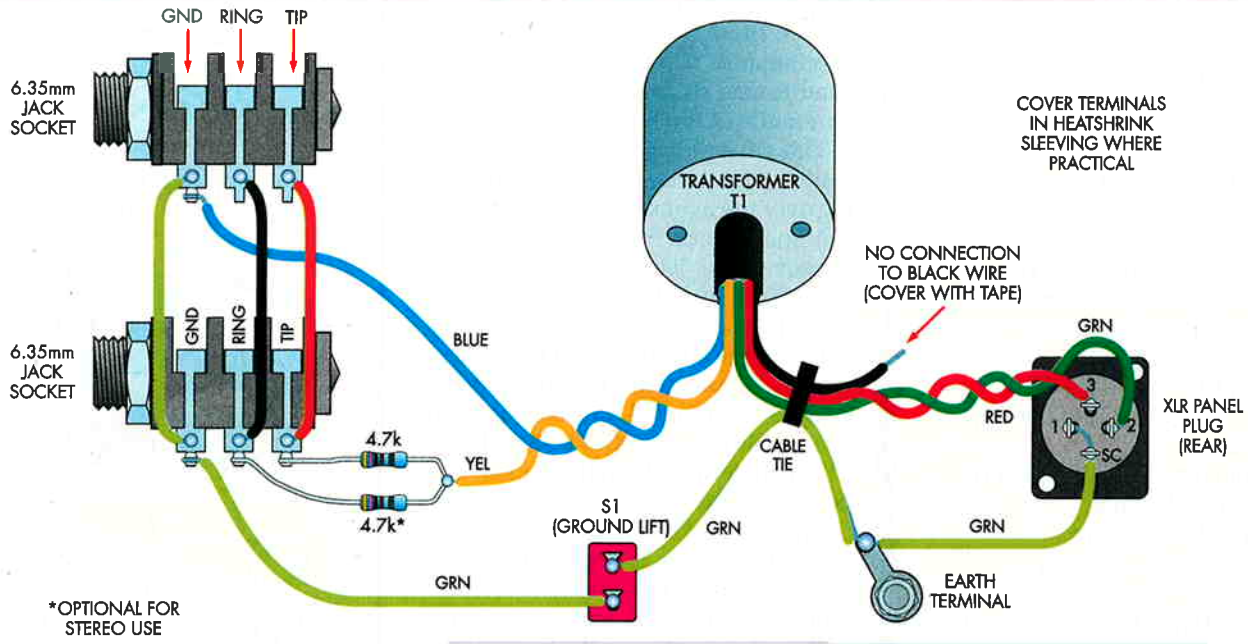


Here's how to wire up the DI Box – compare this with the photo below. No PC board is used because the wiring is so simple.

1 ground on the output plug is passed through switch S1. This provides the ground lift (when open) or a ground connection when closed.

Normally S1 is left closed unless there is a hum loop.

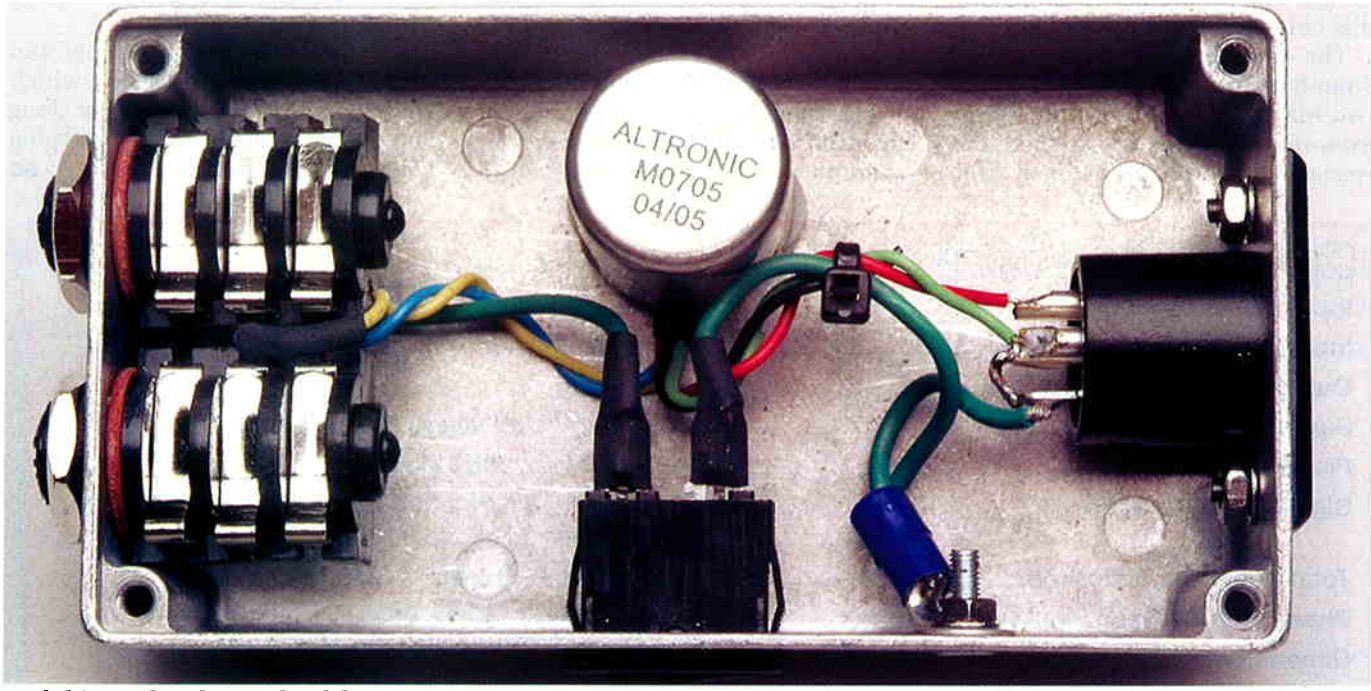
Construction

There is no PC board for this project. This is because there is no need to use one, with all connections being made with short lengths of wire.

Before wiring, the box should be drilled out to suit all the components. The two 6.35mm jack sockets are spaced 22mm apart and require 11mm diameter holes. We placed our sockets 9mm down from the top edge of the box. This makes them sufficiently high in the box so that there is room for the terminals but not so high that they foul the lid.

The XLR plug is located in the centre of the opposite end of the box. Its 19mm mounting hole is made by drilling a series of holes close to the inside of this circumference and then knocking out the unwanted piece and filing to shape. The XLR plug is then secured using two M3 x 10mm countersunk screws, star washers and nuts.

The Ground Lift switch is mounted centrally on the side of the box. Its 19



And this is what the inside of the SILICON CHIP Passive DI Box looks like: 6.35mm sockets on the left, transformer and ground lift switch in the middle and XLR output socket on the right. We covered all exposed wiring with heatshrink tubing.

Parts List – Passive DI Box

1 diecast aluminium box, 111 x 60 x 30mm
1 front panel label, 100 x 50mm
1 10kΩ to 600Ω audio transformer with Mu metal shield (Altronics M-0705) (T1)
2 6.35mm insulated stereo jack sockets (Altronics P-0073, Jaycar PS-0190)
1 SPST rocker switch (S1)
2 4.7kΩ 0.25W 1% metal film resistors
1 crimp eyelet or solder lug with 3mm eyelet hole
4 M3 Nylon washers (or 2 x 3mm spacers)
2 M3 x 6mm countersunk screws
3 M3 x 10mm countersunk screws
3 M3 nuts
3 M3 star washers
1 50mm green hookup wire
1 20mm length of black hookup wire
1 20mm length of red hookup wire
1 100mm cable tie
1 50mm length of 5mm diameter heatshrink tubing

x 13mm cutout is made in a similar way to the XLR socket.

The earthing screw is also mounted on this side of the box. Countersink this hole for the countersunk screw.

The transformer is mounted on 3mm-high spacers and secured with two M3 x 6mm countersunk screws from the underside of the box. The spacers allow the wires to exit from beneath the transformer body. Countersink these holes. If you don't use countersunk screws here, you will need to use some rubber feet on the underside of the box.

The wiring diagram shows how to connect the parts. Fit heatshrink tubing over the exposed terminals on the jack sockets and the switch terminals to prevent the leads coming adrift.

The jack socket terminals will have to be bent over to provide clearance between the terminals and the base of the box. The switched terminals on the sockets are unused and can be bent over at 90° against the socket body. The main terminals on the sockets can be bent about 45° inwards.

The two 4.7kΩ resistors are only needed for stereo mixing but at just a few cents each, you might as well include them for both mono or stereo.

Wire the resistors to the tip and ring terminals and then join them to make the mono connection to T1's primary (yellow wire).

The earth lug is secured to the side of the case and wired to the switch and shield on the XLR socket. Use an M3 x 10mm countersunk screw, star washer and M3 nut to secure the lug in place.

Same-size artwork for the DI Box front panel. There is no front panel/lid drilling required – all holes are on the sides of the box.

Testing

The Passive DI Box is best tested using a signal from an instrument (or signal generator) and measuring the output across pins 2 and 3 of the XLR plug. Set your multimeter to read AC mV, plug the instrument/generator into the DI box and play the instrument.

You should get a signal reading on the meter at about 100mV if the input is around 1V. Set your multimeter to read ohms and check that the ground connection between the instrument's jack plug in the DI Box and the XLR plug at pin 1 can be opened (a high ohms reading) and closed (a low ohms reading) using switch S1.

So there it is: a very simple and even simpler-to-build DI Box which you'll wonder how you ever got along without. Just remember, you can't plug your guitar in directly! SC

Specifications:

Input signal handling:	3.5V RMS
Input impedance:	9.4kΩ (stereo source); 14.7kΩ mono source
Output Impedance:	600Ω (nominal)
Signal Level:	typically 120mV out (balanced) for 1V input
Frequency Response:	within ±0.5dB from 20Hz to 20kHz
Signal-to-Noise Ratio:	-98dB unweighted (22Hz to 22kHz); -101dB "A" weighted, both with respect to 1V input (see text)
Total Harmonic Distortion:	< 0.1% 30Hz to 20kHz at 1V RMS input
Phase Shift Between Input And Output:	-7° at 20Hz, <3° at 100Hz, 0° above 1kHz
Dimensions:	120 x 65 x 32mm overall
Mass:	200g

Direct Injection from a 70V/100V speaker line

by Ross Tester

How do you connect a signal from a 100V (or 70V) speaker line into an amplifier line input?

The question arose while we were discussing roles for the DI Box in the office. But most people would ask "why would you want to connect a 100V speaker line into an amplifier line input?"

Consider two scenarios: in the first, you're installing a large-area PA system which, of course, would use 100V speaker lines to minimise losses in those lines. But you've reached the power output limit of the PA amplifier and still need more speakers to cover the area, possibly quite some distance from the amplifier.

So you have to put in a second (remote) system – amplifier and speakers. But how can you supply it with signal?

Here's an example of a second scenario: at last year's NSW Surf Lifesaving Championships, the carnival was spread out for more than a kilometre along the beach. The surfboat area had one PA system while the rest of the carnival had another, with two panels of announcers used to call the various races. But the referee wanted the race finals in one area to be heard in the other – in other words, two independent systems with the capability of being linked together.

What to do?

Of course, you could run a coax lead all the way back to the first amplifier and use a "line out" (if it has one!). Apart from the cost and inconvenience of such a lead, that can cause problems of its own – not the least noise pickup and line losses over such a length.

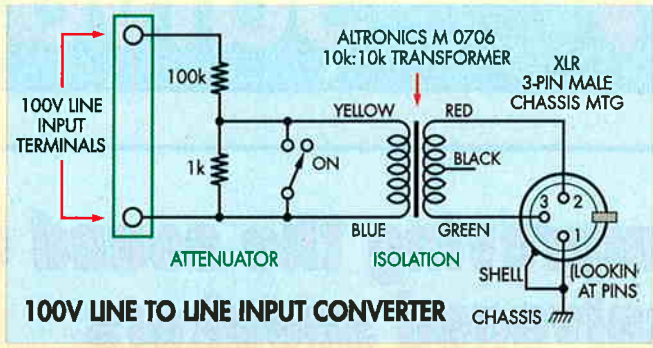
When you think about it, you already have signal close by – on the speaker lines themselves – it's just that the signal is at too-high a level to use in its present state. The level of the signal on the speaker lines depends on the volume set back at the amplifier so effectively, any signal you extract will also be remote-volume-controlled.

But how do you stop the 100V signal destroying your amplifier input (which it no doubt would if you connected it direct!)? Fortunately, the solution is delightfully simple.

Before we look at our approach, we should mention that one of these devices is commercially available from Altronics.

Their A-4902 100V Line Adaptor has a lot more bells and whistles than we are giving, including a volume control and both mic and aux-level outputs. It uses a slightly different (though technically correct) approach as well.

So if you don't want to build a 100V line adaptor, have a look at the Altronics version – (www.altronics.com.au). (In fact, this unit was precisely the solution used for the surf carnival problem).



Commercial alternative: the Altronics A4902 100V Line – Mic/Aux Adaptor.

Anyway, back to our design: all we do is attenuate the signal from the speaker lines with a nominal 100:1 resistive divider, leaving us about 1V maximum at the junction. To isolate the speaker line from the amplifier (and so eliminate the possibility of hum loops) we use a 1:1 audio transformer.

Like the DI Box, we use one of the high-quality Altronics audio coupling transformers, in this case the M0706 10kΩ:10kΩ (the 5kΩ centre tap is not used).

The circuit is housed in a metal box (the same as used in the DI box) with a 2-way screw terminal block on one end for speaker line connection (Altronics P2072A) and a 3-pin male XLR output socket on the other (Altronics P 0807).

The only other "refinement" you could add would be a signal on/off switch – this could be just about any small switch – eg, the rocker switch used in the DI box (Altronics S3220) and the best place to connect it would be across the transformer primary (ie, shorting out the 1kΩ resistor, thus killing amplifier input when the switch was turned on).

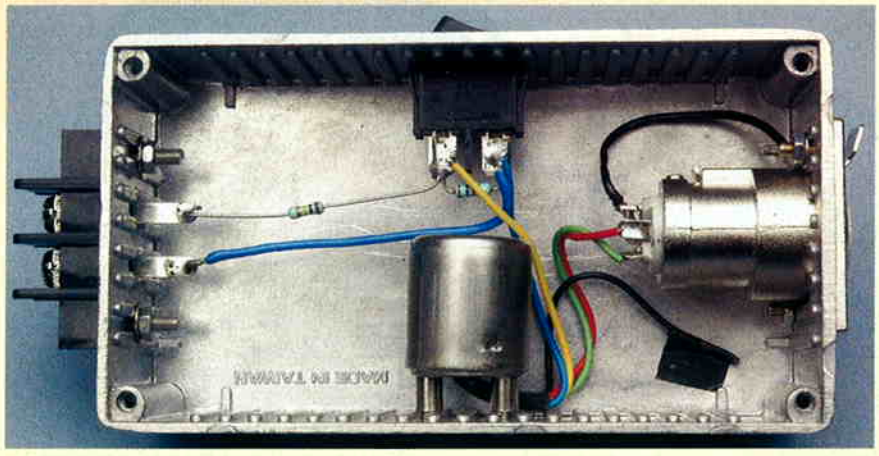
If you don't mind a bit of double-dutch, that means when the switch is turned off, the line adaptor is on, and vice versa.

Construction

Like the DI Box, there is no PC board – it is too simple! We mounted the resistors point-to-point from the input terminals across to the switch and wired the transformer leads direct as well. Note that the centre tap (black) lead is not used.

Again as in the DI Box, connect pin 1 of the XLR socket to the chassis (ground).

And that's it. You can add a suitable label if you wish (we did!) just to make it look professional but that is up to you. There's many a gizmo in the average roadie's box of tricks that has Texta marker or even pencil labelling! SC



Point-to-point wiring is again used for our 100V-line to line-level adaptor.

Salvage It!

BY JULIAN EDGAR

Improving the sound of salvaged speakers

Looking to buy – or scrounge – a secondhand speaker system? There are plenty of bargains around and you can often improve their performance for very little outlay.

This pair of speakers was picked up at a local Salvation Army thrift shop for $10.

One area of consumer electronics that hasn't fundamentally changed over the last 30 years is the design and manufacture of speaker systems. Whether they were originally connected to a record player, tuner, cassette deck or CD player, all boxed speakers use much the same technology. This means that the speakers you can now pick up at garage sales, the tip or secondhand are still very useful, no matter what music source you're using.

But nothing sounds worse than a really horrible speaker, so why bother sourcing cheap or no-cost discards? There are two main reasons: first, there are some very good speakers out there just waiting to be found and second, if you have a half-reasonable starting point, it's not hard to make some major improvements for very little extra money.

Buying speakers

In most cases, you won't have a chance to listen to a speaker that you're collecting, so how do you make any judgements as to how good it will sound? Here are some buying points:

(1) Pick them up and feel their weight. In nearly every case, heavier means better.

(2) Detach the grille and inspect the cones. The roll suspensions should be intact and you should be able to manually move the bass driver back and forth without any binding (or interference) between the voice coil and the dust cap. Be wary if you cannot detach the grille.

(3) Either a ported or non-ported design is fine but in the case of ported speakers, the port diameter should be large enough to ensure that whistling or "chuffing" noises do not occur. In other words, a tiny port diameter with a large diameter woofer isn't a good sign. Very large diameter (but short) ports are also unlikely to be indicative of a good design, as they'll be tuned to a high box resonant frequency.

(4) Check the brand and any labelled specifications (eg, impedance and power handling). Often the specifications aren't very trustworthy but the

Inside each box was a decent small woofer and cone-type tweeter with a single capacitor crossover.

better the brand, the more the figures can be believed.

(5) Make sure that you will be able to later open up the enclosure, either by unscrewing the drivers or by detaching the back.

(6) Assess the condition of the boxes.

Making improvements

Once home, the first step is to listen to your newly acquired purchases. Hmm, sound pretty bad? But what specifically is bad? Is the treble overbright? Is the treble dull? Is the bass lacking, or perhaps all one-note?

Try the speakers on voice as well as on different sorts of music. In fact, listening to the human voice is surprisingly good way of assessing the mid-range response. In addition, PC frequency generator software is freely available on the web and it's well worth downloading a suitable program. This can then be used to drive your amplifier and newly-acquired speakers across a range of input frequencies.

If the speakers sound absolutely awful, just chalk the episode down to experience and go find some more! But if they have potential, there's plenty you can do to improve their performance without much outlay.

Here are some of the problems you might find and what you can do about them:

(1) Problem: Over-Bright Treble

Cure: install a resistor in the feed to the tweeter. Just try some different value resistors and you'll soon get a feel for the changes that can be made. An 8.2Ω 1-watt resistor is a good place to start.

(2) Problem: Poor Treble

Cure: replace the tweeter. Unless you fluke a direct drop-in replacement, this is often most easily achieved by cutting another hole in the baffle and installing the tweeter in a new spot. The old tweeter can then just be electrically bypassed. If the grille cloth is dense and the treble improves with the grilles off, replace the cloth with a design that is more open-weave. (Just go to a dressmaking shop and buy black open-weave scrim fabric that's easy to see through when stretched.)

(3) Problem: Coloured Midrange

Cure: in non-ported designs, place a loose fold of quilt wadding (or fibreglass insulation) inside the box. Aim to fill about 75% of the volume.

Alternatively, in ported designs, staple a thin layer of quilt wadding to the internal panels, making sure you don't block the port. As with grille cloth, quilt wadding is available very cheaply at dressmaking supply shops.

(4) Problem: Poor Bass

Cure: in non-ported designs, fill three-quarters of the box with quilt wadding, as described above. Also, when the speakers are working hard, use a moistened finger to check for air leaks, especially around the terminal block and the edges of the woofer.

In ported designs, try changing the length of the port. Place a rolled-up cylinder of thin cardboard in the port and move it back and forth within the port to effectively lengthen the port by different amounts. Use the frequency generator software and your PC and make lots of listening tests.

The aim here is to reduce any bass resonant peaks – say, over the range from 30–150Hz. In most cases, the port will be too short rather than too long. When you have found the right length, glue the cardboard in place.

The woofer and cone-type tweeter are mounted on a front baffle which is easily removed. Note the rather odd port design and the large gap around the tweeter!

Another oddity was the internal box fill, which was rolled into a cylinder and placed at one end of the box (in front of the port?).

Rat It Before You Chuck It!

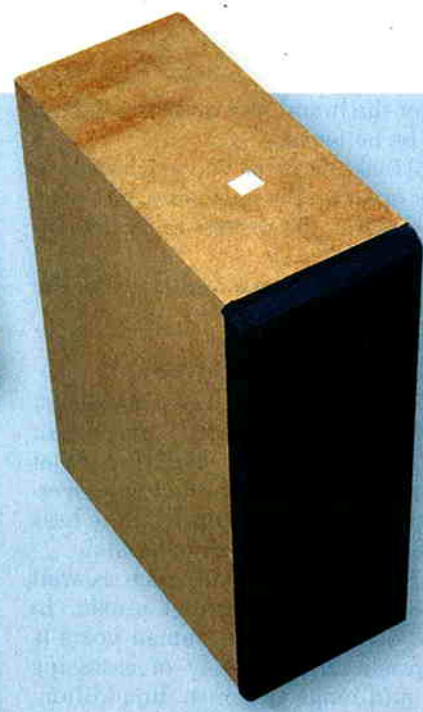
Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

If you have some practical ideas, write in and tell us!

A piece of scrap chipboard was used to close off the opening around the tweeter and the port. This was simply was screwed and glued into place. The tweeter was then re-installed from the front and the gap around its rear magnet assembly closed off with sealant.

Some black spray paint concealed the blanking plate and the changed tweeter mounting.



The grille cloth was reinstalled and the baffle glued back into place. And the results? Comparing the modified and unmodified speakers showed a much more natural sound. All that remains is to paint the boxes and then these will be great for the garage or for the kids.

It's easy to use a spray can to paint the insides of the new port black, so that no-one would ever know! Note that it's no big deal if the port is lengthened so that it protrudes through the front grille – after all, several very well known speakers come like this as standard!

(5) Problem: Speaker Overloads

Cure: if the speaker is easily driven into bass distortion, fit a 200µF non-polarised capacitor in series with it. This will reduce the amount of bass being fed to the speaker and is an ideal approach if you have other speakers in the system (eg, a subwoofer) to provide the required "bottom end".

This also works well if you're using the newly-acquired speakers as extension speakers but still want the main speakers to be powered at high levels. Check out **http://www.jaycar.com.au/images_uploaded/crossovr.pdf** for the crossover frequencies that various values capacitors give in systems with different impedances.

(6) Problem: Cabinet Finish

Cure: unless you've got yourself a really high-quality design, it's usually not worthwhile spending hours improving the finish of dilapidated boxes. However, one quick and easy approach is to give the box a quick rub back (or if it's a plastic finish, a wipe over) and then spray-paint the box flat black. It won't come up with that famed "piano" finish but the poor surface will no longer stand out and the boxes will look quite neat!

Finally, note that the sound that the speaker makes can be dramatically altered by its room placement. If they lack bass response, put them in the corners of the room. If the bass is strong and muddy, bring them out from the corners or even try raising them off the floor them on stands. Similarly, if the treble is muted, raise the speakers so that the tweeters are at ear level when you're seated.

Always try moving speakers around – if you haven't done this before, you'll be amazed at how much you can vary their sound.

More internal fill (based on old quilt wadding) was added to supplement the original fill, which was replaced more loosely in the enclosure.

Conclusion

You don't have to spend a fortune to get good sound from low-cost secondhand speakers, In fact, with just a little work, you can often get them to outperform many mini and midi-sized off-the-shelf systems. **SC**

NEW KITS COMING SOON..... Mid. May

K234 DC PUMP CONTROLLER KIT

This kit will drive our AC pump (PUMP2) (variable up to 400L p/h.) from 12VDC like a battery or solar panel. The PCB has 2 surface mount MOSFETs already mounted, you just fit the other components. Ideal for use with our K009D solar charger & K237 low battery cutout kit. Kit inc. PCB, all onboard components. K234: $16. Kit with pump (K234P) $24

K237 LOW BATTERY VOLTAGE CUTOUT

This kit has a number of applications but was designed to disconnect a 12 or 24V battery when the battery voltage drops to a pre-setable limit. Ideal for use with our K009D solar charger & K234 Pump controller. Req. a small amount of fine soldering. Kit inc PCB and all onboard components. (K237) $19

K009D SOLAR BATTERY CHARGER KIT

This kit is designed to efficiently charge 12V or 24V batteries from solar panels. Simply turns off the charging current when the battery float voltage is reached, & turns on when the battery voltage drops a preset amount below the float voltage. Ideal for use with our K234 pump controller & K237 low battery cutout. Kit is supplied with PCB and all on-board components.(K009D) $25

K235 PICSTEP STEPPER MOTOR DRIVER

This simple to build kit uses a SN754410 chip and is designed for use with PICAXE or other microprocessors. Features include LED output indication. Kit includes PCB and all onboard components.(K235) $19

K238 24 WHITE LED 50mm LAMP

This kit has a 50mm diameter PCB and is designed to fit into a downlight fitting. Ideal for use with solar or battery lighting systems Kit includes PCB and all onboard components with 24 X 20,000mCd LEDs.

K231 LONG RANGE 2 CH UHF REMOTE CONTROL RECEIVER WITH 80A LATCHING RELAYS

This kit uses 2 X 80A latching relays that only draw current while changing state. The transmitter used for this kit is our K190A (not included in this kit). The K190 has 4 buttons (A, B, C & D). Relay 1 uses button A for ON & B for OFF, Relay 2 uses button C for ON & D for OFF. This type of operation take away the guess work if you can't see or hear what you are turning on or off. Kit includes PCB and all onboard components including 2 X 80Amp latching relays. (K231) $38

K142D NEW UNIPOLAR (5/6 WIRE) STEPPER MOTOR DRIVER

This kit is designed to work with our K142 series of kits (see our Website for more details). To get the best performance from this kit it is best used with our K142C constant current driver. The kit contains PCB and all onboard components. (K142D) $27

4-CH UHF RECEIVER KIT WITH LIMIT / RESET INPUTS: This kit is almost identical in its function to our K180B but is pre-built (requires soldering of 2 wires). Has individual limit/reset input for each channel. Combined with our TX8 Transmitter, this kit can control any combination of four output relays in either momentary or latching operation. Features inc. range of ~50m, indicator LEDs, & screw terminals for ease of use. Receiver (K238) $30. TX8 transmitter $15.

To be notified the moment that these kits and other items kits become available subscribe to our mailing list at

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IN STOCK ELECTRIC MOTORS, BATTERIES & SPEED CONTROLLERS 100W, 200W, 280W & 500W

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(es5KG) NEW 5KG ELECTRONIC SCALE KIT:

This kit comes with the electronics assembly (70 X 38 X 10mm) pre-built end tested. All you need to do is mount the electronics assembly, buzzer, it's load cell and connect to 3VDC. Features include: 1gm / 1OZ. resolution, metric or imperial, LCD display, clock, countdown timer and low battery warning. Load cell 12 X 12 X 80mm.

(es20KG) NEW 20KG ELECTRONIC SCALE KIT:

This kit comes with the electronics assembly (141 X 46 X 10mm) pre-built end tested. All you need to do is mount the electronics assembly, it's 2 load cells and connect to 3-6VDC. Features include: 1gm / 1OZ / 1LB resolution, LCD display, low battery warning. Load cell 12 X 12 X 80mm.

(es180KG) NEW 180KG ELECTRONIC SCALE KIT:

This kit comes with the electronics assembly (103 X 46 X 12mm) pre-built end tested. All you need to do is mount the electronics assembly, it's 4 load cells and connect to 9VDC. Features include: 1gm / 1OZ / 1LB resolution, LCD display, low battery warning. Load cell 7 X 29 X 35mm. $35

RX434A SUPERHETERODYNE RECEIVER MODULE:

Pre-built superheterodyne surface mount receiver module which is crystal locked at 433.92MHz. It has a high sensitivity, operates from 5V DC supply. It is designed for use with TX434A. When used with TX434A, the pair can give a range over 1km if powered by 9VDC.

Frequency:433.92MHz
Transmit rate: 9.6KB/S
Modulation: A.S.K.
Voltage:5VDC @ 2.6mA
Size: 35mm X 17mm
(RX434A) $8

TX434A SUPER-REGENERATION TRANSMITTER

MODULE: Pre-built superheterodyne surface mount crystal locked 433.92MHz. 3-12V DC. When use with RX434A. can give a range of over 1km if powered by 12V

Frequency:433.92MHz
Transmit power: 10mW @ 12V
Modulation: AM
Voltage:3-12VDC @ 15mA
Size: 14mm X 14mm (TX434A) $6

NEW LED MR16 TYPE LAMP

These lamps are a direct replacement for MR16 halogen down lights. they will operate from 12V AC or DC at 150mA making them ideal for use in solar installations. During May you can buy a ceiling gimble mount with socket for just $2 with every lamp purchased (subject to availability). (LED21W) $13ea

ADD $2 extra for a gimble ceiling fitting during may (GLED21) $15

OZONE & NEGATIVE ION GENERATORS from $12

All operate from 12V-30mA DC..
Produce up to 10KV OUTPUT
Info on Web Site..
These could suit other applications like Electrostatic Speakers etc.

Warning: Ozone destroys mould and germs and is used in water purification systems. Its concentration has to be limited for humans. Research before using!

For more info and pricing go to our Website.

COIN HOPPER WITH COIN DISPENSING / COUNTING MECHANISM.

This mechanism was designed as part of a vending machine, it suits $1AU coins. It has a 24V motor & gearbox (all metal gears) & an optical switch to count coins. At 1.8V the motor will start running, it is difficult to stop the output shaft with your fingers at this voltage.

The two 8mm gearbox output shafts turn in opposite directions, they have a flat on each & our SPR300 sprocket fits the shaft. The combination of our SPR300 11 tooth sprocket & our CHAINSP 80 tooth chain and sprocket set would give a slow & powerful output (approx. 15RMP @ 24V or 0.96 RPM @ 2V). This motor & gearbox with chains & sprockets could be used to open doors & gates etc. (see our garage door controller kit K023C).Some approx. voltage/current & RPM figures of the motor/gearbox. 2V 80mA 7RPM, 6V 100mA 30RPM, 12V 120mA 60RPM, 18V 140mA 110RPM, Overall dimensions of the hopper assembly: 93mm(W) X 126mm(L) x 126mm(H).

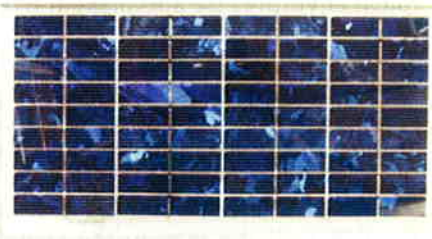
USED FLUKE 8020-B MULTIMETER... Limited stock!

These well known, high quality multimeters have a 3.5 Digit LCD display with all of the basic features you would need in a multimeter. It has overload protection of transients up to 6 kV. Other features include battery eliminator jack for benchtop use. The 8020B is ideal for troubleshooting circuit boards, relays, cables switches, and for finding intermittent shorts or open circuits. User manuals are available on the FLUKE Website. With new but not original leads. (8020B) $33

K229 AUDIO / VIDEO TRANSMITTER / RECEIVER KIT

These kits (K229TX & K229RX) were designed to transmit and receive video and stereo audio. The TX has been designed to be as small as practical. (TX kit) 13mm(H) X 30mm(W) X 30mm(D). (RX kit) 17mm(H) X 50mm(W) X 62mm(D) with connectors). Construction is simple and the pre-built modules mean minimal work is required and there is no tuning to be done. The antenna can be as simple as a 31mm length of un-shielded stiff wire or another antenna can be connected remotely via co-ax cable. An antenna such as our K198 2.4GHz TX / RX ANTENNA KIT can be added. This antenna kit will increase the range of the K229. The K198 is a 2.4Ghz antenna printed on a circuit board, it has been tested with our previous A/V TX/RX kit and gave good a good image at over 100M. These kits are designed to operate from a 9VDC supply.

NEW SOLAR PANELS



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20W (SP20): $219
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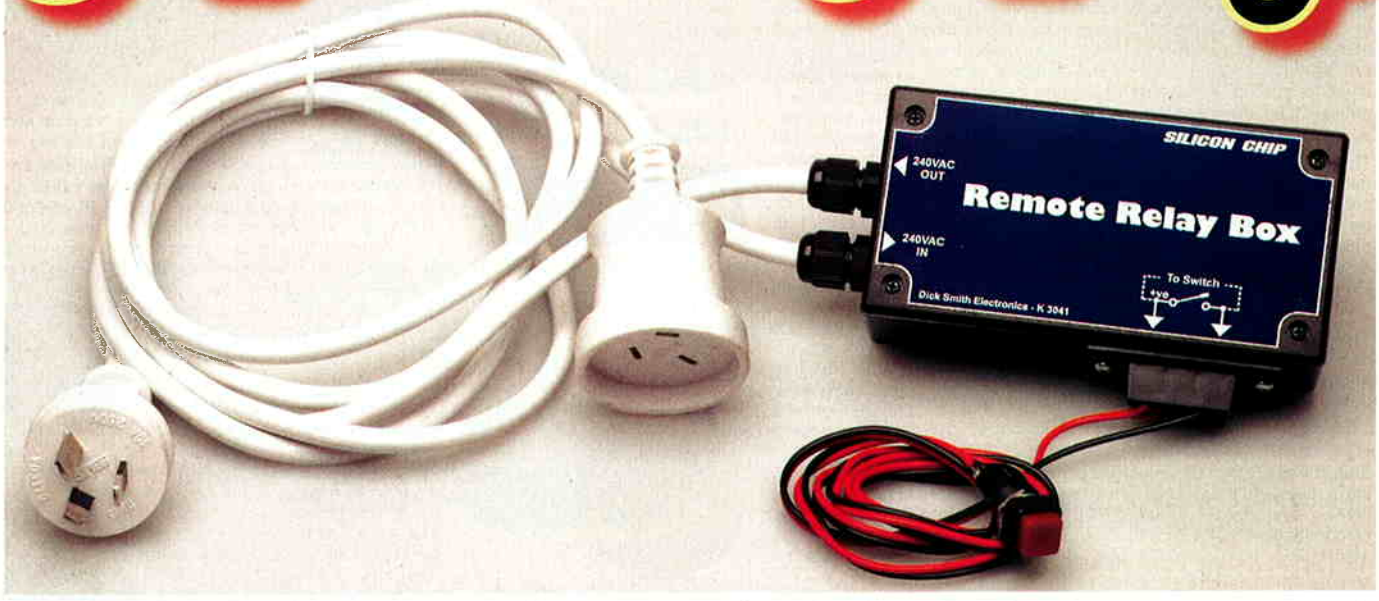
major credit cards accepted, Post & Pack typically $7 Prices subject to change without notice ACN 068 740 081 ABN18068 740 081

Remote Relay



This has to be one of the simplest projects ever: it's basically just a power supply, a relay and a switch. Yet if you've ever had to safely switch mains voltages, you'll know this can also be one of the handiest projects ever.

Design by Bill de Rose*

Switching mains voltages is pretty simple. All you have to do is make sure the switch you use is rated at 240VAC (or more) and that it will handle the current you expect to switch – with a little bit of margin for safety.

Oh, then you have to ensure that all the "bitey" bits are fully insulated. And that the switch can't work its way loose. And that if one of the wires breaks or works its way off, it can't touch anything else and make it live. And that . . .

And what if you wanted to switch 240VAC mains some distance away – say switching some garden lights at the back of your yard from inside the house?

Sure you can run mains cables from the lights all the way to the switch and back again but apart from the expense, you now have mains-carrying cable which has to be properly conduited, buried and marked with locating tape so someone doesn't put a shovel through it somewhere down the track!

Of course that means getting an electrician in because you can't legally install fixed mains wiring yourself . . .

It's not quite as simple as you first thought, is it?

All this assumes a mechanical switch: one that is actuated by the pressure of your fingers (or something similar). But what if that switch needed to be actuated by something else – a sensor of some sort, a computer output or another relay in another project?

It's now a whole new ball game. Instead of a switch, you now need a relay, rated to handle that same mains voltage and current we talked about earlier.

Here's a good example: the famous Dick Smith Electronics "Fun Way Into Electronics" books have quite a number of projects with relay-switched outputs.

But none of those relays are suitable for switching mains voltages. In fact, there are specific warnings about doing so (apart from the fact that beginners and mains don't mix well!).

The relay contacts in most cases aren't rated for 240VAC mains and even worse, there are exposed tracks on the PC board which were never designed to carry mains.

If you need to have one of the "Fun Way" projects – or anything like them – switch a mains device on and off, you need the project we are describing here.

As we said in the introduction, it is very simple indeed: a power supply which will energise a relay if the "switch" is in the on position.

That relay is rated to carry mains voltages and it's also rated to carry

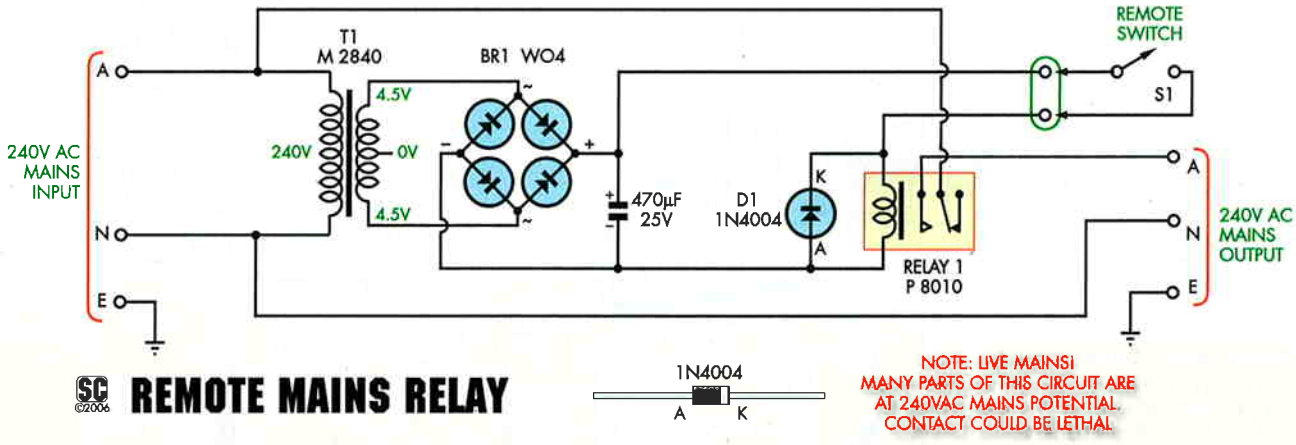


Fig.1: when we said it was simple, we meant it! Just a simple mains power supply to drive a relay – and some form of remote switch make up the project.

fairly high current – we'll look a little closer at this aspect later.

The "switch" can be any form of device capable of closing and opening the circuit. That includes a switch, a relay or some form of switching semiconductor, such as a transistor – and again, we'll see how in a moment.

Because the switch is in the low-voltage section of the circuit, it is completely safe. So you can run a pair of wires down the back yard – even along the fence if you like – and they can never hurt anyone. Importantly, because they carry only the small relay coil current (~60mA), the wires can be quite thin, subject to voltage drop over the distance.

The circuit

Now have a look at the circuit in Fig.1. Mains power (240VAC) is stepped down to a safe level (9V) by transformer T1. This transformer has a centre tap which is not used, so the full 9V AC from the two red leads is applied to the bridge rectifier, BR1. If the 470µF filter capacitor was not in circuit, we would have a DC voltage of about 12V peak at the bridge output, pulsating at 100Hz (double the mains frequency of 50Hz).

The filter capacitor charges up to the full peak voltage and tends to stay charged at or near this voltage while ever the current drawn is kept to a reasonably low level. Therefore you end up with close to 12V DC from a 9V AC transformer.

When switch S1 (whatever form it takes) closes, current flows through the relay, to switch whatever is connected to the mains output.

The relay contacts are rated at 240VA and 10A – which, not coincidentally, is the maximum current you can draw from a domestic power outlet. The mains lead, too, is rated at 10A.

But we'd be hesitant about drawing 10A through any "normal" extension lead – we've seen too many melted plugs and sockets.

Why the diode?

Most of the time, diode D1 does absolutely nothing. And if you only ever switched this circuit with a mechanical switch, it isn't even necessary. But if you switch it with any form of semiconductor (a transistor, for example, or a PC output), it becomes essential.

Normally (ie, with the relay energised) the diode is reverse-biased (because the cathode is connected to the positive supply), so it is turned off. It's only when power is disconnected (ie, the switch is turned off) that the diode briefly comes into play.

When the switch is opened, the current which was holding the relay coil energised suddenly drops to zero, so the magnetic field around the relay coil collapses.

This induces a brief but significant

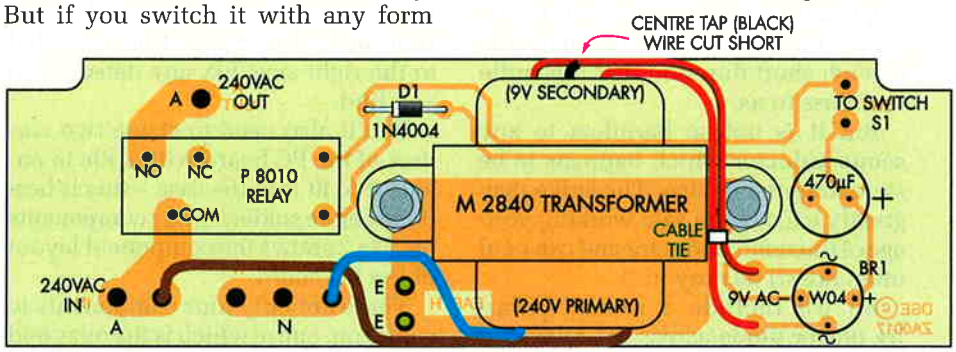
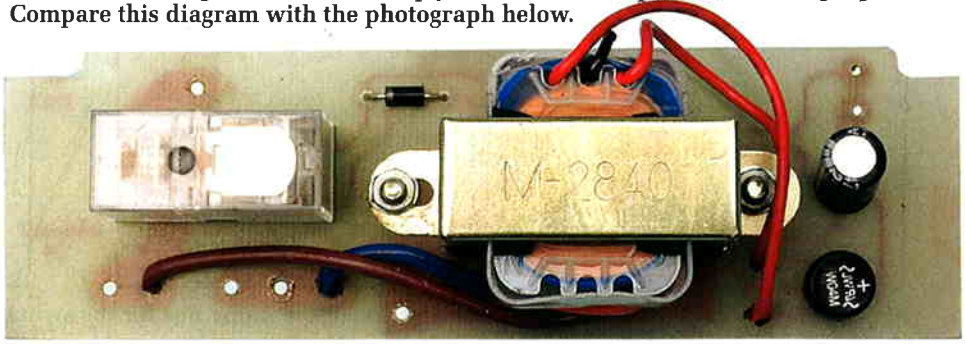


Fig. 2: the PC board overlay shows the components mounted on the top side (ie, non copper side) as if in an X-ray looking through the board. Note how the board top edges are shaped – these allow the lid to fit on the box. None of the external wiring is shown in this diagram – this is to help you solder all components in the right places! Compare this diagram with the photograph below.



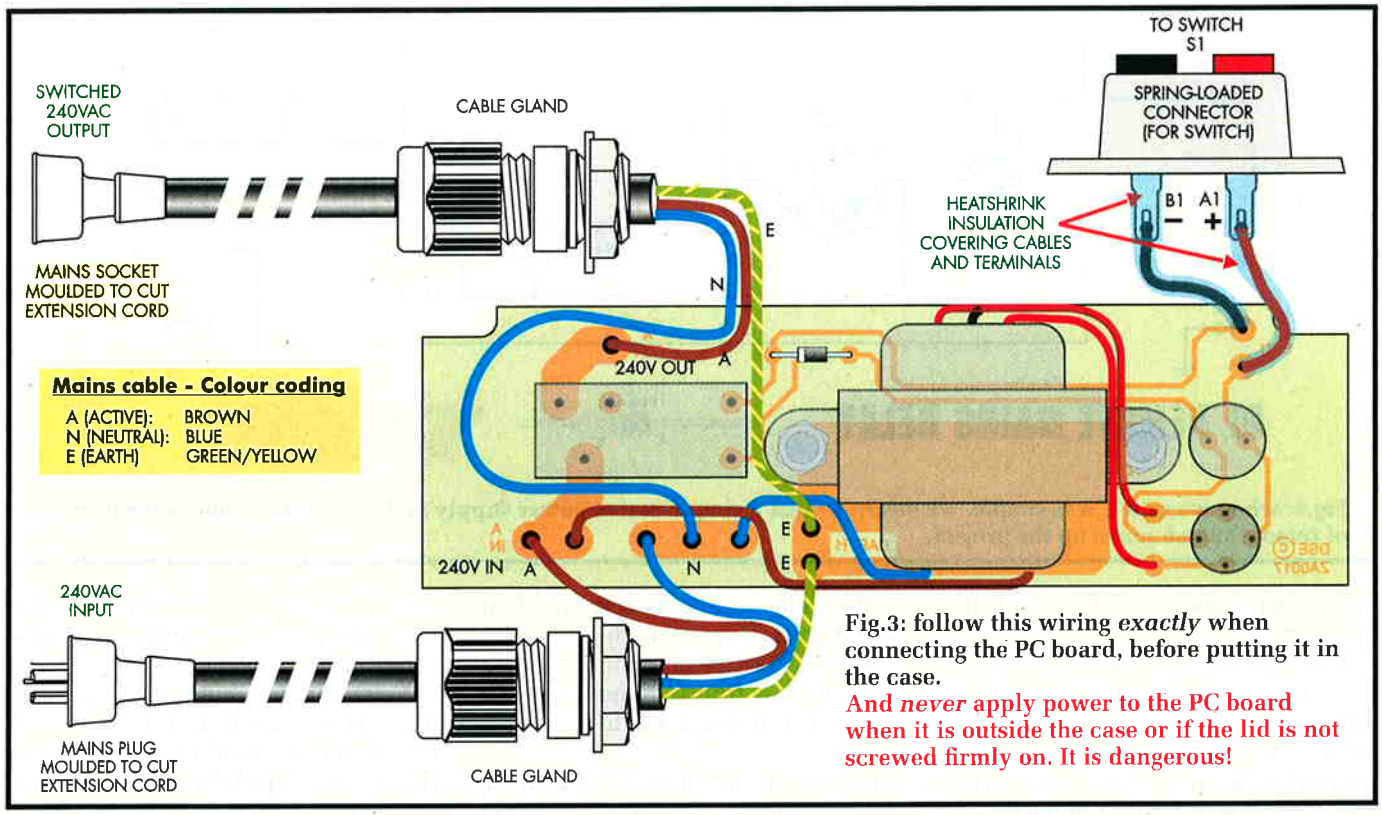


Fig.3: follow this wiring *exactly* when connecting the PC board, before putting it in the case.
And *never* apply power to the PC board when it is outside the case or if the lid is not screwed firmly on. It is dangerous!

voltage in the relay coil with the reverse polarity to what was there under power. You may see this described as a back-EMF (EMF stands for electromotive force).

It's called a "spike" and it can briefly measure several hundred volts! Even though the voltage is high (and you can feel it tingle if you get your hands across the relay coil terminals), it is of such short duration that it is quite harmless to us.

But it is not so harmless to any semiconductor which happens to be switching the device. The spike may greatly exceed the safe working voltage of the semiconductor and can (and often does!) destroy it.

So we include a reverse-polarity power diode across the relay coil which effectively short-circuits that voltage spike, making it harmless.

Building it

The first thing to do is check your PC board for any defects. What you are looking for is under-etching, where tracks might be shorted together; over-etching, where tracks might be broken, or sometimes holes which haven't been drilled or haven't been drilled to the right size. Fix any defects that you find.

You'll also need to shape two corners of the PC board with a file to enable it to fit into the case – this is best done before soldering any components on. Fig.2 shows the component layout of the PC board.

There are only four components to solder on, one of which is the relay and it will only fit one way. The other three are all polarised; that is, they must be soldered in the right way around or the project won't work. All components should be mounted as far down on the PC board as they will easily go – but don't force them.

On diode D1, note which end the band (cathode) is – it's easy to get right. Likewise, the polarity marks on the capacitor: most have a row of "-" symbols down the side closest to the negative lead. Sometimes, though, you will find capacitors with + markings instead – but they too are pretty easy to identify.

The last polarised component is the bridge rectifier, BR1. It will have either moulded or printed "~" (tilde) symbols on two of the legs marking the AC inputs. Get these right and the + and – leads, which should also

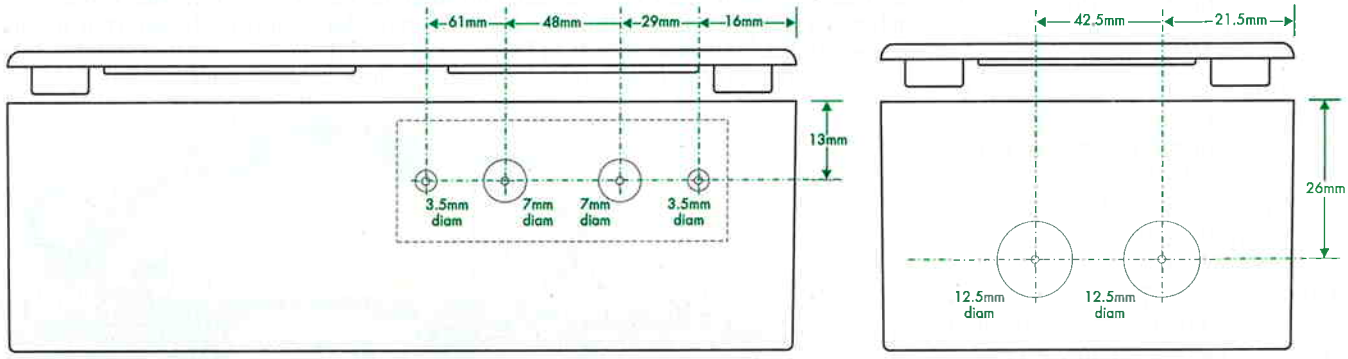
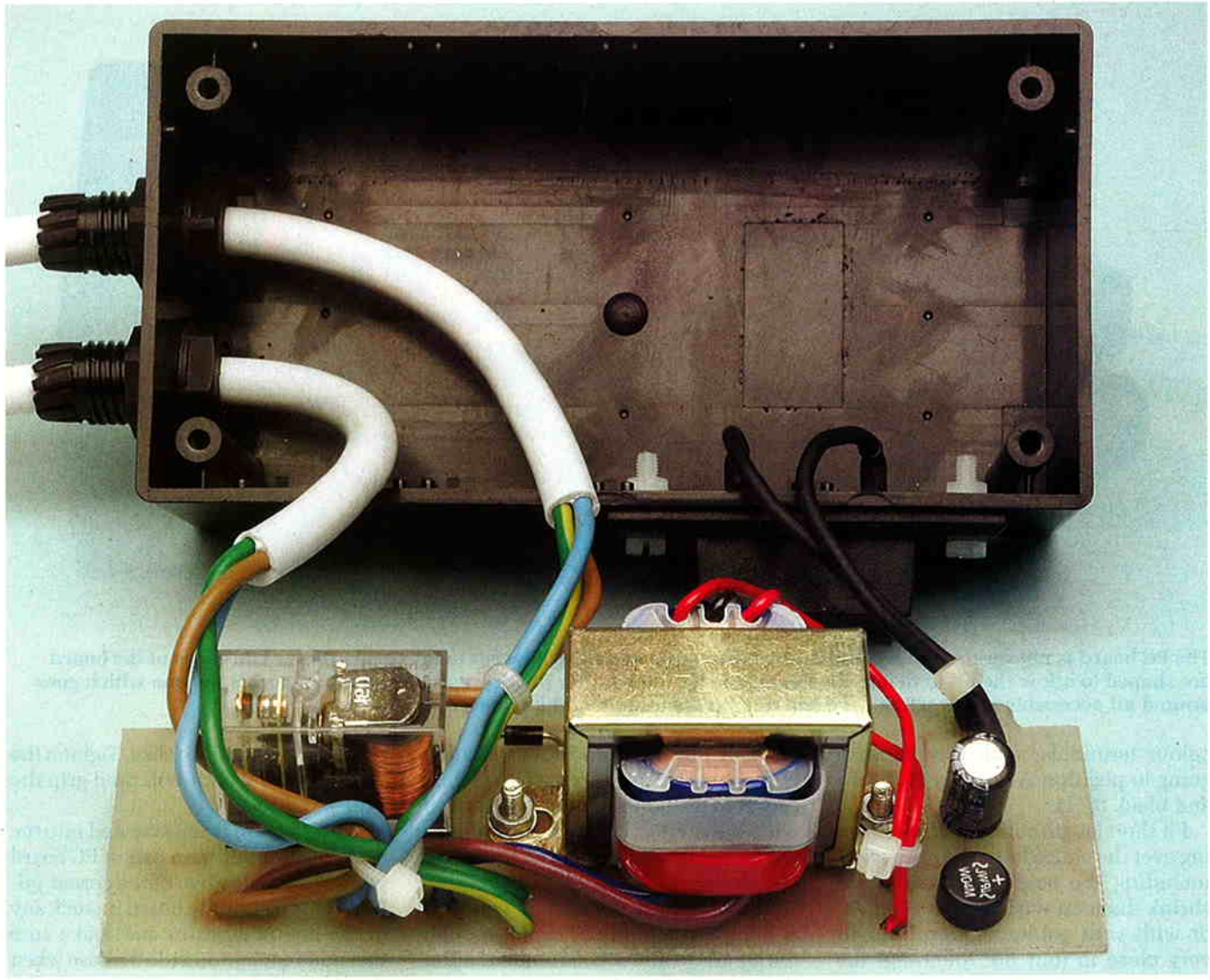


Fig. 4: where to drill the holes in the side and end of the Zippy Box for the switch terminal block (left) and cables glands.



Compare this photograph with the diagram at right. In this shot, you can clearly see four of the five cable ties we added around wiring to keep it all together, along with the nylon screws and nuts which secure the two-way terminal block.

be identified, should drop into the right holes.

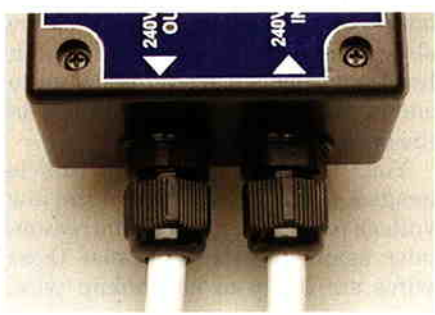
The only two bits left are the relay, which we have already mentioned and the power transformer. It screws to the PC board with M3 bolts and nuts – make sure you tighten them well and also use a star washer under the nuts to prevent them vibrating loose.

The two red wires from the transformer (the 9V AC secondary) solder to the PC board alongside the transformer, next to the bridge rectifier.

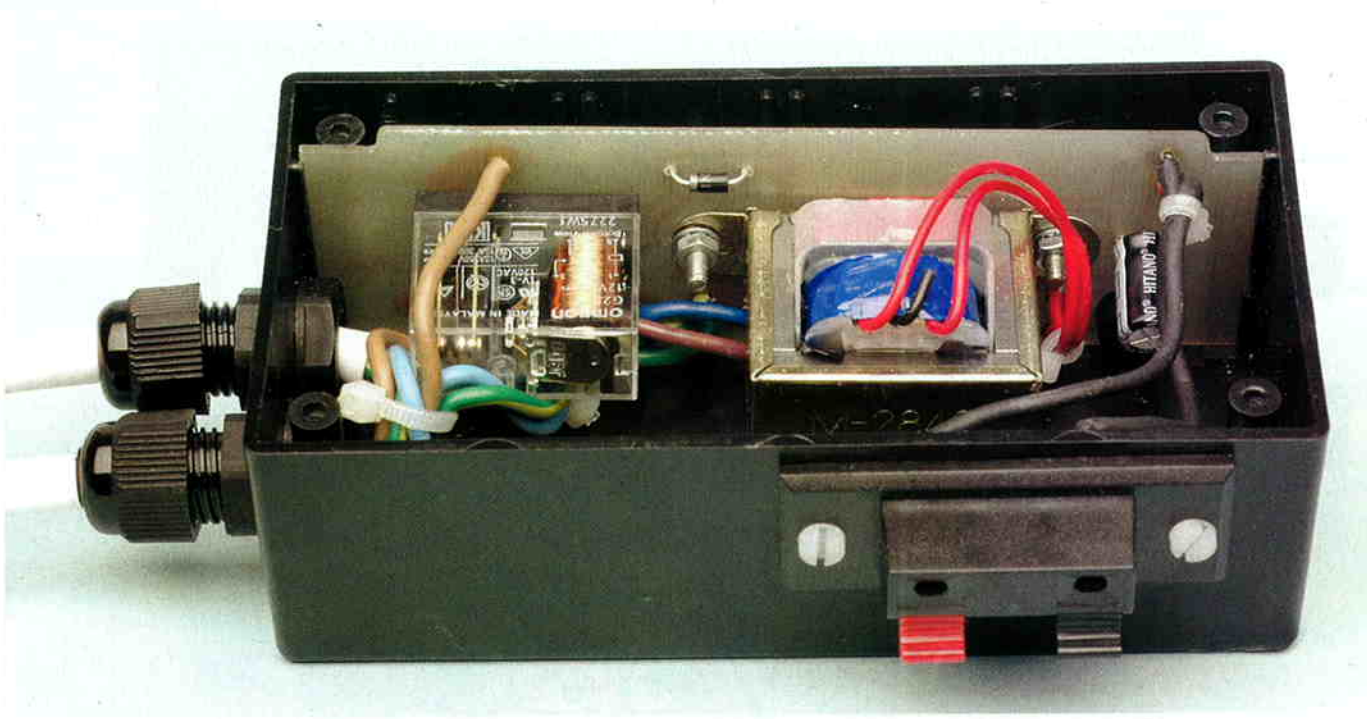
Switch wiring

The remote switch connects to the circuit via a pair of spring-loaded terminals mounted on the outside of the case. To do this you will first need to drill some access and mounting holes in the case – see Fig.4 for drilling details. The terminal block should be mounted on the case with Nylon screws and nuts.

Inside the case, these connect to the appropriate point on the PC board via short lengths (say 70mm) of hookup wire. Normally, using a standard switch, polarity will not be important. But if you are going to switch the relay via a PC, transistor switching, etc, polarity is important so you should use red and black wires on the same



(Left): the input and output mains leads (which are an extension lead cut into two) pass through cable glands which grip the cables and hold them tight.
(Right) the switch connections, being low voltage, use a speaker terminal with wires going off to the switch



The PC board is not screwed in but slides down two pairs of guides adacent to the corner posts. The edges of the board are shaped to allow the lid to fit on. The final cable tie, added after the PC board is slid into place, is the one which goes around all accessible mains wires – the one right in the middle of the picture.

colour terminals, with the red wire going to position A1 on the PC board and black to B1.

Fit short lengths of heatshrink sleeving over the entire length of each wire, including the solder terminals and shrink them on with a hot-air blower or with your soldering iron brought very close to (but not touching) the sleeving.

Mains wiring

The kit will be supplied with a 2.5m mains extension lead, which must be cut and the various wires soldered to the appropriate points on the PC board. It doesn't matter where you cut the lead – ours was half way but your application might require the relay box closer to the power point or closer to the other end – it's up to you.

Start by drilling the mains input and output gland holes in the case (see Fig.4).

Then cut the mains lead where you want to and remove about 70mm of outer insulation. Take extreme care when you do this that you do not nick or damage the insulation of the mains wires underneath. Remove the inner insulation of all wires so you have about 20mm of bare wire.

Fit the two glands to the case and tighten them. Now slide the gland covers over the wires and then pass the wires through the appropriate glands (input to the bottom, output to the top with the switch connector on top of the case) but do not tighten the gland covers yet.

You will find it easier if you pull at least half a metre of cable through the glands to allow you room to solder the wires to their respective places on the PC board. They are all identified – just make sure you don't mix up the input and output cables or the Active, Neutral and Earth wires: Active wires are the brown ones, Neutral are blue and the Earth wires are green with a yellow stripe.

Push the bare ends of the mains wires through their appropriate holes in the PC board but before soldering the mains wires in place, twist the bare ends of adjacent wires together under the PC board using a pair of pliers. This gives them some mechanical stability in case the soldered joint gives way.

Before soldering, check that you have only twisted together pairs of actives (brown) and pairs of neutrals (blue). If you are satisfied that all is well, solder the twisted pairs to the PC board.

When soldered, pull the cables back out through the glands so that only a couple of millimetres of outer insulation shows inside the case. Tighten the gland covers which will then grip the cables tightly.

The PC board is not screwed into the case – it slides down a pair of PC board guides, closest to two of the corner pillars. As you slide the board in, tuck any of the mains wires in and make sure that none emerge outside the case when the lid is placed in position.

Cable ties

Five small cable ties are fitted to the wiring inside the case – their positions can be seen in the opened out and "assembled" photographs.

They're not just there to make it all neat – though they do that! The reason for fitting these ties is to ensure that any loose ends cannot move around in the unlikely event that any of the wires comes loose.

As well as a cable tie securing the "switch" wiring (ie, from the PC board to the spring terminals) we also covered both of these wires with lengths of heatshrink tubing – up to and including the solder terminals on the back of the terminals.

You might wonder why this is needed, as these wires are in the low voltage part of the circuit. The reason, once again, is safety: because these wires are likely to be hookup wire,

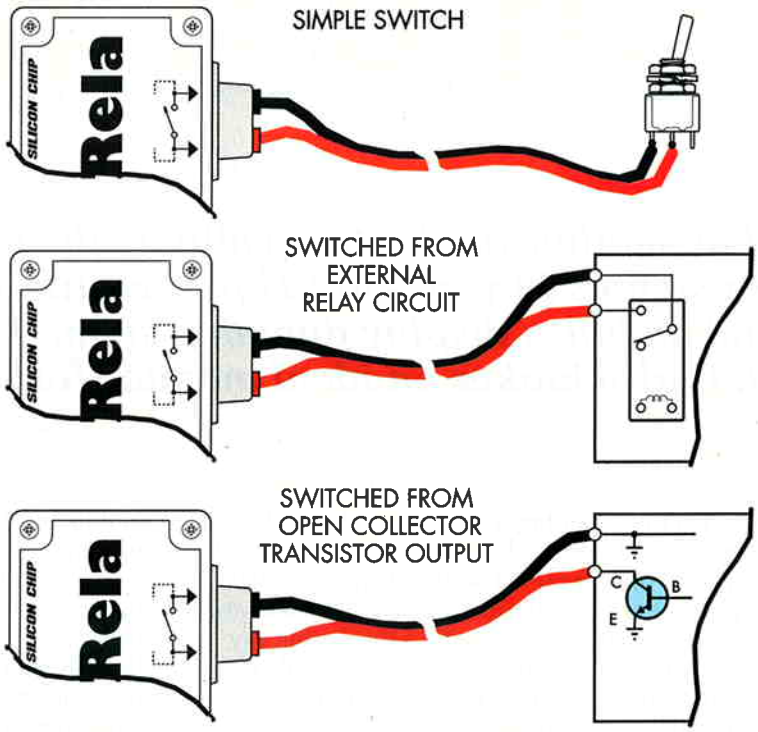
Parts list – Remote Mains Relay

1 UB3 Zippy Box (130 x 68 x 44mm); [DSE H-5003] with front panel label
1 PC board, code ZA-0017, 125mm x 38mm
2 cable glands, 4-6mm diameter
1 polarised spring terminal block
1 mains extension cord with moulded 240V plug and socket, length to suit
1 mains transformer, 9V AC secondary (DSE M-2840)
1 relay, 12V (200Ω) coil, SPDT contacts rated at 10A, 240V (DSE P-8010)
1 1N4004 silicon power diode
1 W04 bridge rectifier, 400V @ 1.5A (DSE Z-3304)
1 470µF, 25V electrolytic capacitor
2 10mm M3 screws with nuts and shakeproof washers
2 10mm M3 nylon screws with nuts and shakeproof washers
5 small cable ties
Short lengths red and black insulated hookup wire
Short lengths heatshrink tubing
2-core cable and switch as required for remote switching (see text)

Where to get the kit . . .

This project was devised and produced by Dick Smith Electronics, who retain copyright of the PC board pattern. A full kit of parts (Cat. K-3041) is available from all Dick Smith Electronics stores and DSE online (www.dse.com.au) for $34.80

Just some switching options . . .



Here we show three different possibilities for using the relay box (yes, there are many more!).

At the top is conventional switching, using virtually any form of switch you can lay your hands on. Or, as we said in the article, even twisting together two bare wires!

Next down is using a project relay circuit to switch this relay (as we mentioned, many relays used are not mains rated – this is the way to switch mains using these relays). You would normally connect as shown to have the circuit operate when the project relay pulls in; however you can have the reverse with the relay box relay operating when the project relay drops out simply by connecting to the "NC" and "COM" terminals instead of the "NO" and "COM" as shown here.

The third circuit shows how to use a transistor to switch the relay box. With an NPN transistor as shown applying bias to the base will cause the transistor to turn on and the relay box relay to pull in. Again, this could be reversed by switching with a PNP transistor with its base normally held down to earth via a resistor; a voltage applied to the base would turn the transistor off and the relay box relay would drop out.

their insulation is almost certainly not mains rated. If any of the mains wires come loose and happen come into contact with the switch wires, we want to ensure that their insulation is more than good enough to prevent any possibility of mains voltages getting through to the switch terminals, the switch or its external wiring.

That's also the reason we use nylon screws and nuts to hold the spring terminal plate in place.

Finishing off

The kit should be supplied with a self-adhesive label; if so, fix it in place and put the lid on the box. The four screws are hidden by small pips. Apart from testing, you have now completed the Relay Box.

Testing

Don't plug it in yet!

With your multimeter on a low Ohms range, check to see that you have continuity (zero ohms or close to it) between the two earths on the plug and socket and between the two neutrals on the plug and socket. Check that you have ***no*** reading between the actives on the plug and socket and between any pins on the mains plug and socket and the switch spring terminals.

If you have the opposite on any of these tests, something is seriously wrong and must be fixed before powering up.

If all is well, plug into power and use, say, a 240VAC bedlamp or other 240V device on the socket end. Turn power on – both on that device and the mains outlet to which the relay unit is plugged in – and absolutely nothing should happen!

Now short out the switch terminals with a short length of wire and the light should come on. Remove the short and the light should go out. It's that simple! SC

*Dick Smith Electronics

Vehicle Multi-V

Want to monitor the battery voltage, the airflow meter or oxygen sensor signals in your car? This versatile voltage monitor can do it all and includes display dimming so the LEDs are not too bright at night. It also makes an ideal monitor for a battery charger.

There are many voltages within a vehicle that can be monitored simply by attaching a meter to the source of the signal (or voltage) to be measured. This can give the driver information about the operation of various sensors and voltages within the engine bay.

When monitoring these voltages, it is not usually necessary to obtain a precise value of the voltage but the general trend of the voltage is sufficient.

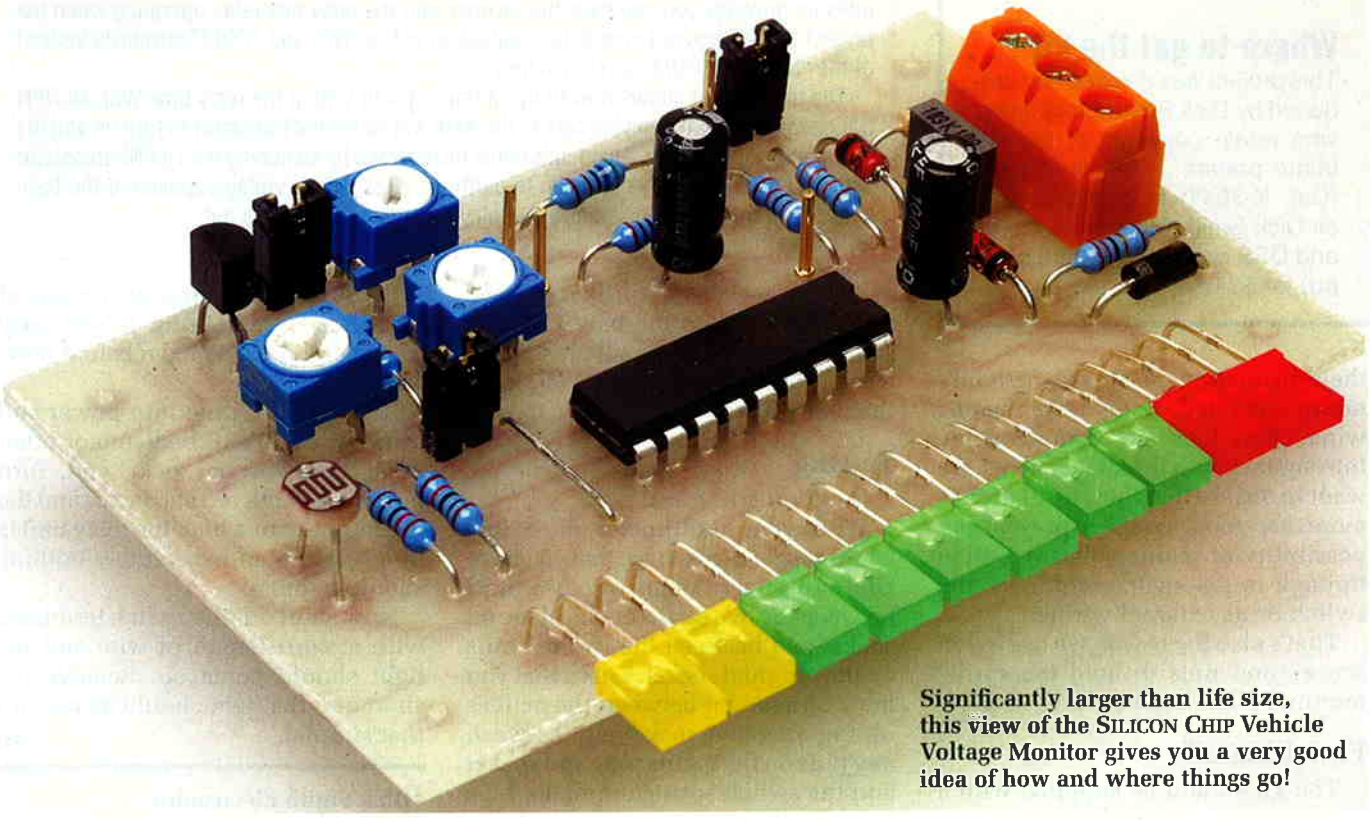
Our Voltage Monitor provides for monitoring some of the most common voltages within a car. A 10-step bargraph lights LEDs in response to the measured voltage.

With low voltages applied to the Voltage Monitor, the low LEDs light and for high voltages, the upper LEDs light. Voltages in between are shown by the middle LEDs.

Some sensor voltages will alter simply due to the loading of a meter. Therefore, these require a meter that does not present any appreciable load on the sensor.

For example, the oxygen sensor that is used to monitor the correct burning of the fuel, typically has a voltage output between 0 and 1V, with the mid-way voltages indicating that the fuel is burnt correctly. A low voltage (near to 0V) indicates that the air-fuel mixture is too lean and a high value (approaching 1V) indicates a too-rich mixture. The voltage from these sensors also changes at a rapid rate as the engine management system continually monitors and changes the air-fuel mixture to ensure it is running at the correct (stoichiometric) mixture.

The SILICON CHIP Vehicle Voltage Monitor is easily set up to monitor a nominal 0-1V range. It also provides minimal loading on the sensor's output.



Significantly larger than life size, this view of the SILICON CHIP Vehicle Voltage Monitor gives you a very good idea of how and where things go!

oltage Monitor

by John Clarke

A typical response curve is shown overleaf of an oxygen sensor for rich, lean and stoichiometric mixtures. The curve is very steep at the stoichiometric position and covers a voltage range that is typically 0.2V to 0.8V.

The stoichiometric mixture ratio is normally maintained by the engine management system to ensure minimum exhaust emissions when used in conjunction with a catalytic converter.

When the car is running you will see that the display will move rapidly up and down this steep part of the curve as the engine management unit maintains the correct mixture. On engine over-run, the mixture may go lean. When the engine is loaded, the mixture will go into the rich portion of the curve to provide more engine power.

Other sensors

Other sensors within a car have a 0-5V range. These include airflow meters, MAP sensors and some later model air/fuel ratio sensors. For these signals, the Voltage Monitor can be set to show the full range from 0V up to the maximum of 5V. It is also possible to narrow the voltage range that is measured and shown on the display.

For example, you may wish to monitor between 0.5V and 4.5V. To do this, it is just a simple adjustment of the upper and lower voltage limits with trimpots.

Other types of voltages that can be measured are those that do not normally drop to 0V but vary by a small amount from a typical fixed level. An example of this is the car battery. This is generally at 12V but can fall to around 10V when the starter motor is starting the engine and rise to 14.4V when the battery is fully charged.

When measuring this narrow voltage range we are not particularly interested in what is happening below, say, 10V because it should normally never happen.

So in this case it is best to set up the metering so that

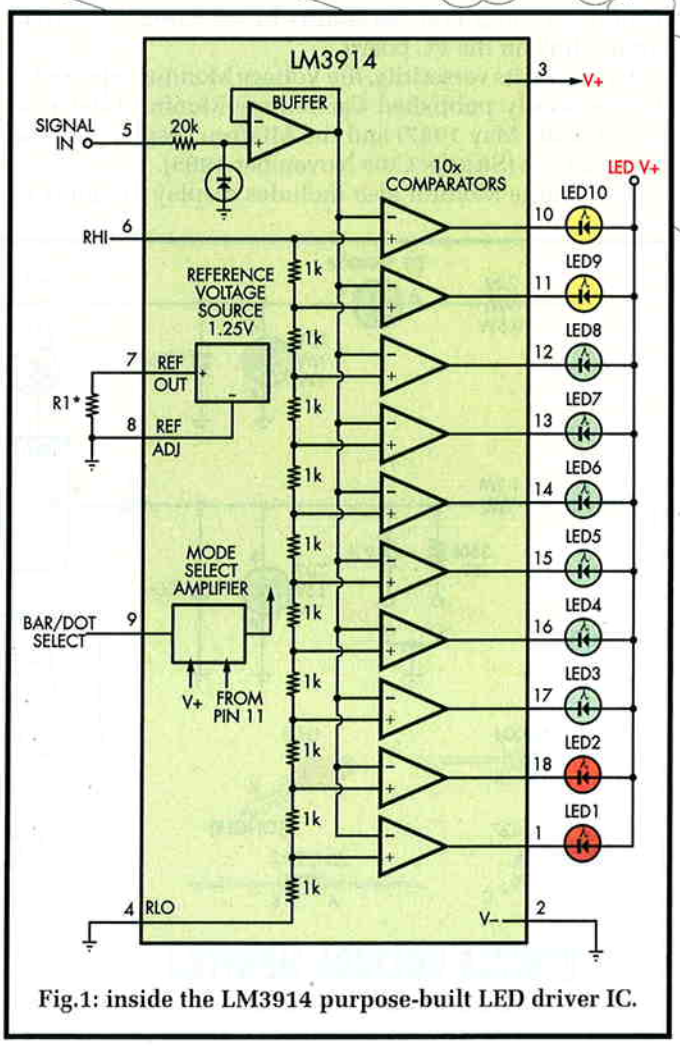


Fig.1: inside the LM3914 purpose-built LED driver IC.

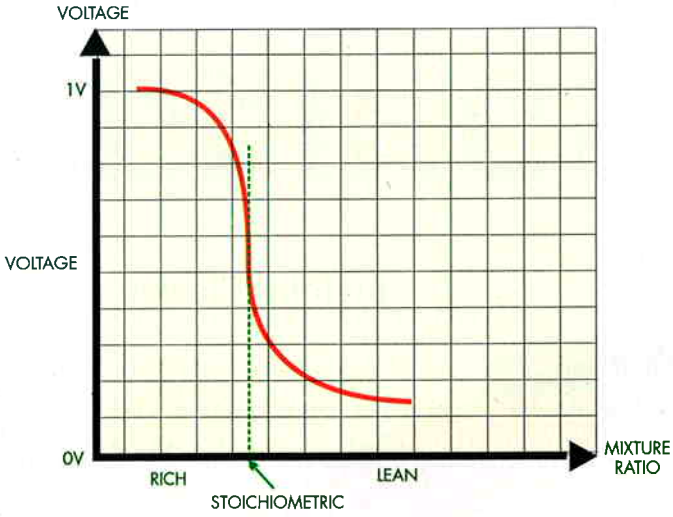


Fig.2: the voltage output from the oxygen sensor follows an "S" curve from 0-1V with the ideal, or stoichiometric, mix part-way down the curve. The voltage actually varies up and down the curve as the engine management system tries to keep the fuel delivery system as efficient as possible.

the lower LEDs show down to around 10V and the upper LEDs show up to say, 15V. This is called an expanded scale meter and is easily set up with the Voltage Monitor.

The Voltage Monitor is set to measure one of the above mentioned voltage ranges simply by selecting the correct jumper link on the PC board.

Because of its versatility, the Voltage Monitor supersedes the previously published Car Battery Monitor (Electronics Australia May 1987) and the Mixture Display for Fuel Injected Cars (SILICON CHIP November 1995).

The Voltage Monitor also includes display dimming so that the display is not excessively bright at night.

The circuit

Circuitry for the Voltage Monitor is based around an LM3914 10-LED bargraph display chip. This drives 10 LEDs sequentially from the lowest LED, when the voltage measured is low, through to the highest LED when the upper voltage range is reached.

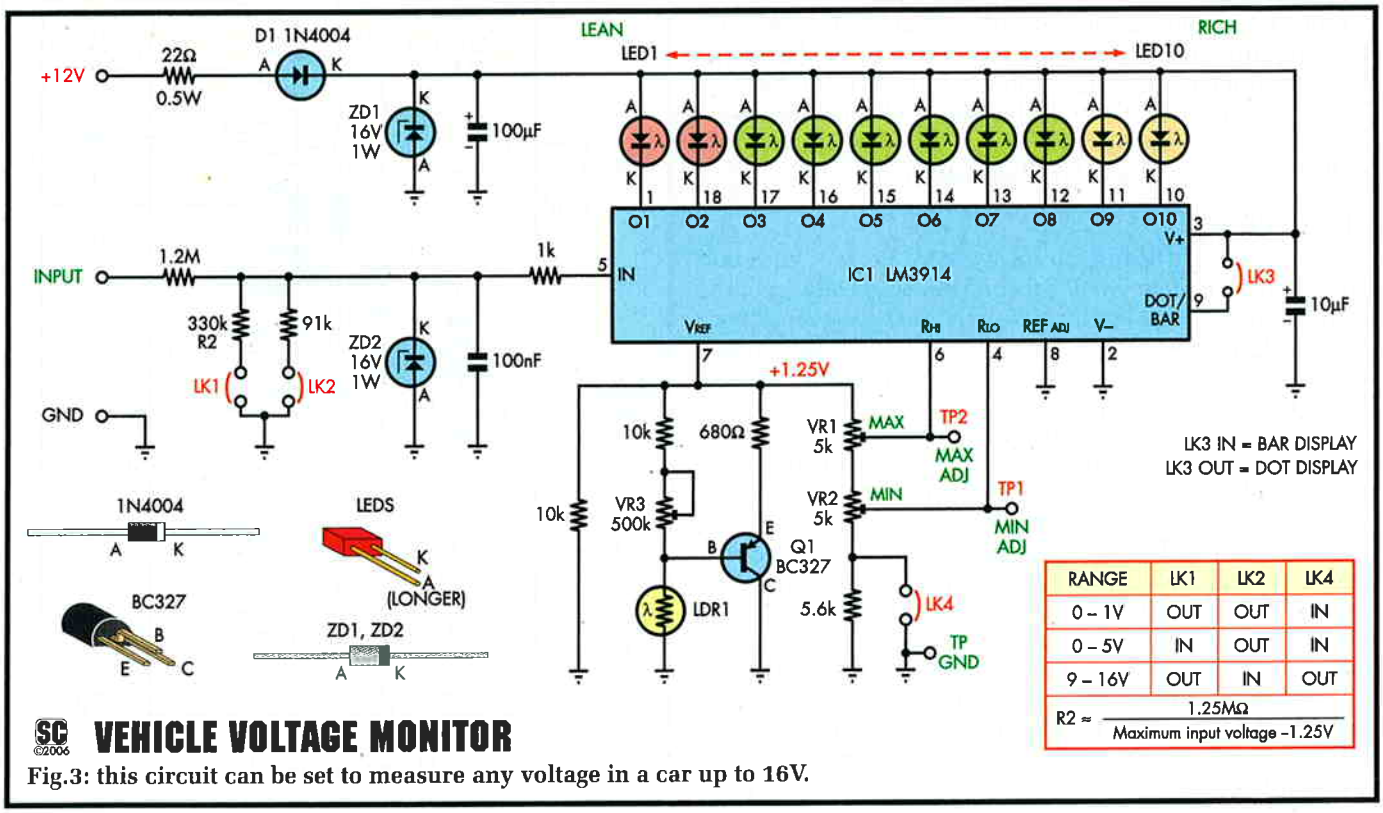
The IC gives the option of showing this as single LEDs (dot mode) or as a sequentially increasing number of lit LEDs as the voltage rises for the bar mode. In dot mode, two adjacent LEDs may be alight at the switching threshold.

Refer now to the internal diagram of the LM3914 (Fig.1). 10 comparators monitor the voltage applied to pin 5. The comparator's positive inputs are connected to 10 series-connected resistors between the R_{LO} and R_{HI} inputs. To make measurements of voltage, the R_{HI} input is connected to a voltage source, while R_{LO} is either connected to ground or an elevated voltage, if you wish to measure a range of voltages that start above ground.

The resistor string sets each comparator at a different voltage. For example, if R_{HI} (pin 6) is connected to a 1V supply and R_{LO} (pin 4) is set at 0V, then each comparator will differ at its positive input by 100mV. So the lowest comparator will have 100mV at its positive input, the next comparator will have 200mV, the next will have 300mV and so on up to the 1V level for the top comparator.

When a voltage is applied to the IC's input, LED1 will light for voltages above 100mV. At 200mV, LED2 will light and so on. Finally, LED10 will light at 1V. Whether the lower LEDs remain lit or extinguish as a higher LED lights depends on whether the IC is set to display in bar mode or dot mode.

The LM3914 includes a voltage reference which can be used to set the R_{HI} level. This reference has a nominal 1.25V



RANGE	LK1	LK2	LK4
0 – 1V	OUT	OUT	IN
0 – 5V	IN	OUT	IN
9 – 16V	OUT	IN	OUT

$R2 \approx \frac{1.25M\Omega}{\text{Maximum input voltage} - 1.25V}$

Fig.3: this circuit can be set to measure any voltage in a car up to 16V.

between pins 8 and 7. We can derive a 1.25V reference by connecting pin 8 to ground.

Incidentally, the current through the LEDs is set at about 10 times the current flow through R1. So if pin 7 is at 1.25V and we use a 1kΩ resistor for R1, there will be a 1.25mA current through R1. The LED current is therefore about 12.5mA. This current determines the brightness of the display.

All this is shown opposite in the circuit for the Voltage Monitor. R_{HI} and R_{LO} inputs are provided with voltage via trimpots VR1 and VR2 that form a divider across the 1.25V reference. The divider can include a 5.6kΩ resistor if link LK4 is not connected or alternatively, the lower end of VR2 connects directly to ground if LK4 is connected. LK4 gives the option of selecting an R_{LO} voltage that starts well above 0V when the link is out or providing an R_{LO} voltage that is at 0.63V or lower when the link is installed.

As mentioned, the current from pin 7 to ground sets the display LED brightness. We take advantage of this fact to include display dimming. Dimming circuitry is made up using a Light Dependent Resistor (LDR1), VR3 and the series 10kΩ resistor, transistor Q1 and the 680Ω resistor.

It works as follows: in bright light, LDR1 has a low resistance (around 10kΩ), so the base of Q1 is pulled toward the 0V rail. Since the emitter of Q1 is only 0.7V above the base, it follows that there will be somewhere around 0.55V across the 680Ω resistor (Reference voltage [1.25V]-0.7V=0.55V). This sets the current flow from pin 7 to ground at its maximum. Therefore the LEDs are at their brightest in bright light.

At low light levels, LDR1 has a high resistance, so the base voltage for Q1 moves substantially higher than it was under bright light. As a consequence, Q1 is almost switched off. Current through the 680Ω resistor is therefore minimal and the overall current from pin 7 to ground is set by the effective resistance still connected. This comprises the 10kΩ resistor and the VR1, VR2 and 5.6kΩ resistor string.

VR3 sets the dimming threshold. At its minimum resistance, the base of Q1 will not fall below about 1.25V/2 because of the voltage divider action of the 10kΩ resistor in series with VR3 and the 10kΩ light resistance of LDR1. Thus dimming will occur even at relatively bright levels. Winding VR3 for more resistance will set the base of Q1 lower at the bright ambient light levels to increase the brightness. In practice, VR3 is adjusted to start dimming as the ambient light falls.

Signal for the pin 5 input of IC1 is processed to keep the voltage to within the 1.25V maximum range set by V_{REF} at pin 7. For the 1V signal from an oxygen sensor, the signal is passed through a 1.2MΩ resistor to provide a high input impedance load, filtered with a 100nF capacitor. Pin 5 has a very small input current, typically 25nA, so there will be less than 30mV across the 1.2MΩ input resistor. The 16V zener ZD1 protects pin 5 from transients that could otherwise destroy the IC.

When measuring voltages above the 0-1V range, the input needs to be attenuated so that pin 5 still only sees a voltage within the 0-1.25V range. When measuring 0-5V, link LK1 is inserted so that the voltage is reduced using the 1.2MΩ series resistor and the 330kΩ resistor to ground. The division by these two resistors reduces the 0-5V signal at the input to a 0-1.08V range at pin 5. Similarly, when measuring

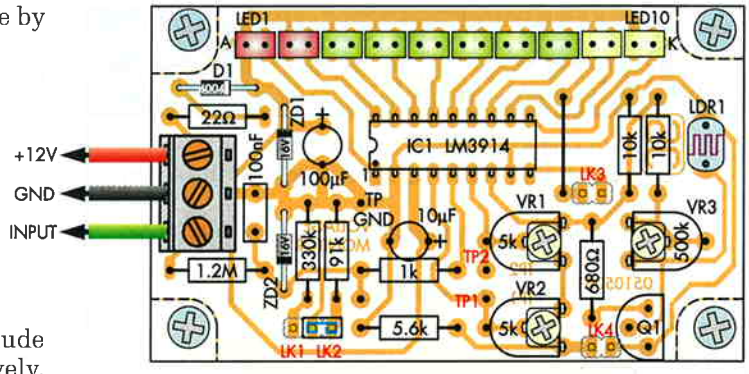
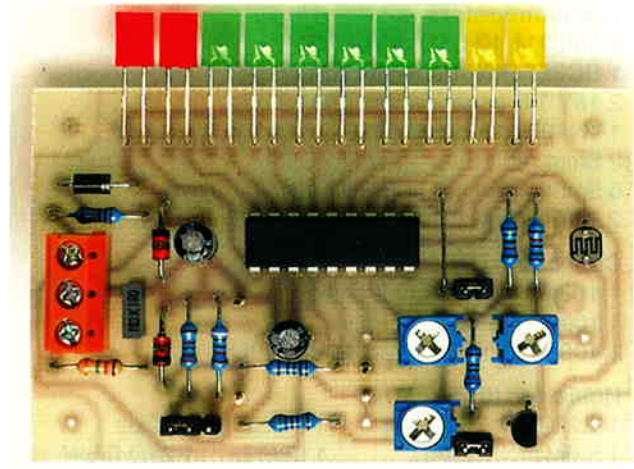


Fig. 4: here's the component layout diagram with matching photograph underneath. Take care when placing the LEDs!



the 16V range, link LK2 is installed to reduce the signal at pin 5 down to 1.13V. This reduction in voltage is achieved with the 91kΩ divider resistor.

For other voltage ranges, the value of the attenuating resistor will need to be calculated. To do this, take 1.25V away from the maximum expected input voltage and then divide this into 1.25MΩ. For example a 10V range will require a nominal 150kΩ resistor (1.25MΩ/ (10-1.25) or 142kΩ).

The final display range is set using VR1, VR2 and link LK4. VR1 sets the point at which the maximum LED lights. VR2 sets the point which the input must reach before the first LED lights. By removing LK4, this R_{LO} level can be raised higher by including the 5.6kΩ resistor in the series string with VR1 and VR2.

Power for the circuit is obtained from a 12V supply. This would normally be from a car battery via the ignition switch. For other purposes, a supply from 6V-15V will be suitable. Diode D1 protects the circuit from reverse connection of the supply. The 22Ω resistor and ZD1 help prevent transients from damaging IC1. The 100µF capacitor filters the supply and also removes transients.

The 22Ω resistor also acts to dissipate power when IC1 is connected in bar mode (when link LK3 is in circuit). In the bar mode the IC dissipates more power, so some of this power dissipation is shared in the resistor instead. It is not recommended to use the display in bar mode when the ambient temperature is above 40°C and the supply is at 15V. This is because the IC could overheat under the high temperatures and power dissipation. The IC can easily drive the display in dot mode even on the hottest of days in a vehicle.

Parts List – Vehicle Multi-Voltage Monitor

1 PC board coded 05105061, 79 x 47mm
1 3-way PC mount screw terminal block with 5.08mm pin spacing
1 LDR with 10kΩ light resistance Jaycar RD-3480 or equivalent) (LDR1)
1 7-way pin header (broken into 2 x 2-way and 1 x 3-way)
3 jumper shunts
3 PC stakes
1 50mm length of 0.7mm tinned copper wire

Semiconductors
1 LM3914 10-LED driver (IC1)
1 BC327 PNP transistor (Q1)
2 16V 1W zener diodes (ZD1,ZD2)
1 1N4004 1A diode (D1)
2 5mm red LEDs (LED1,LED2)
6 5mm green LEDs (LED3-LED8)
2 5mm yellow LEDs (LED9,LED10)

Capacitors
1 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 100nF (0.1µF) coded 104 or 100n

Resistors (0.25W, 1%)

1 1.2MΩ	1 330kΩ	1 91kΩ	2 10kΩ
1 5.6kΩ	1 1kΩ	1 680Ω	1 22Ω 0.5W

1 500kΩ horizontal trimpot (code 504) (VR3)
2 5kΩ horizontal trimpot (code 502) (VR1,VR2)

Miscellaneous
Automotive wire, solder.

Construction

The Vehicle Voltage Display is constructed using a PC board coded 05105061 and measuring 79 x 47mm. It can fit into a small plastic UB5 box measuring 83 x 54 x 31mm if required. However, our experience is that many constructors of the Fuel Mixture Meter and similar projects like to mount the LEDs behind the dash, so we are presenting the unit as a bare PC board.

Begin by checking the PC board for any possible shorts between tracks, breaks in the copper and for holes that are not drilled. Start by installing the wire link and resistors. The accompanying table shows the resistor colour codes but it's also advisable to check them with a digital multimeter, as some colours can be difficult to decipher.

The diodes, Q1, the capacitors and trimpots can go in next, along with IC1. Take care to orient the diodes, IC1 and the electrolytic capacitors as shown. Now install the 3-way terminal block and the two and three pin headers for the link shorting plugs. Also insert the PC stakes at test points TP1, TP2 and TP GND.

Finally, install the LDR and the LEDs. The LDR can go in either way, but the 10 bargraph LEDs must all be installed with their anodes (the longer of the two leads) to the left.

Depending on how you wish to install the display in the car or piece of equipment, you may wish to set the LEDs parallel to the PC board. This means that you need to bend the LED leads over at 90° so that they are in line with the edge of the PC board – see photo. Alternatively, you can mount the LEDs vertically so that they later protrude through a slot in the lid of a case.

Install the links (LK1-LK4) according to your application. A table showing the link connections for the 0-1V, 0-5V and 9-16V ranges is shown on the circuit diagram.

LED colours

Note that our prototype uses red LEDs for LEDs 1 & 2 and yellow LEDs for LEDs 9 & 10. This because we envisage that the most popular use for this project will be a fuel mixture meter, monitoring a vehicle's oxygen sensor. In this case, you want lean mixtures to be shown with red LEDs, indicating DANGER for your engine.

For other applications though, say monitoring your battery voltage, you might want to have red LEDs for LEDs 9 & 10, because in this case a battery voltage up around 15V indicates over-charging, another DANGER condition.

Installation

You will need to make three wiring connections to your car. It's easiest to do that at the ECU, so you will need to have a wiring diagram showing the ECU pin-outs. The four connections are: (1) +12V (ignition switched); (2) chassis (0V); and (3) sensor or car battery signal. The car battery signal is best taken at a point close to the battery for best accuracy without incurring voltage drops across the wiring in the vehicle.

Use the car's wiring diagram to find these connections and then use your multimeter to check that they're correct (eg, when you find the +12V supply, make sure that it switches off when you turn off the ignition).

In addition, you have to confirm that there is a fluctuating signal in the 0-1V range on the oxygen sensor lead (the car

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1.2MΩ	brown red green brown	brown red black yellow brown
❑	1	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	1	91kΩ	white brown orange brown	white brown black red brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	5.6kΩ	green blue red brown	green blue black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	1	22Ω (0.5W)	red red black brown	red red black gold brown

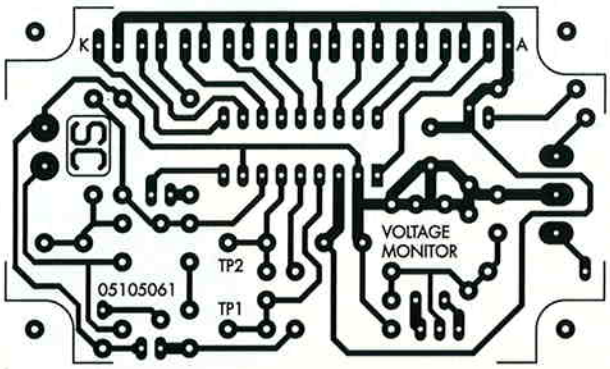


Fig. 5: full-size PC board pattern for etching your own board or checking a commercial board.

will need to be fully warmed up) or that the signal coming from the airflow meter, or MAP sensor changes when the throttle is blipped.

Note that the 0V connection for the Voltage Display should be made at the ECU or to a terminal that is secured directly to a chassis point.

Setting up for an oxygen sensor

Links LK1 and LK2 should be out and link LK4 installed.

(1) Set trimpot VR1 fully clockwise and trimpot VR2 fully anticlockwise.
(2) Start the car, let the oxygen sensor warm up and confirm that the LED display changes.
(3) Go for a drive and briefly use full throttle. The end yellow LED should light up. Back off sharply – the end red LED should light.
(4) Check that the LEDs travel back and forth when the engine is at idle.
(5) If the end yellow LED never lights, even at full throttle, adjust VR1 so that it lights when the mixtures are fully rich.
(6) In normal driving, the LED should move back and forth around the centre LED. If the oscillations are all down one end after adjusting VR1, adjust VR2 to centre the display.

Setting up for a 0-5V airflow sensor

Link LK1 should be installed and LK4 out.

(1) Set trimpot VR1 fully clockwise and trimpot VR2 fully anticlockwise.
(2) Adjust VR2 so that the lowest LED just lights on an engine over-run (when you are going downhill in gear with the engine slowing the car down).
(3) Adjust VR2 so the top LED just lights on maximum acceleration.
(4) Repeat the adjustments, since adjusting VR1 and VR2 will affect one another to a small degree.

Setting up for a battery monitor

Link LK2 should be installed and LK4 out.

(1) Use a multimeter to measure the battery voltage. Now with the engine running fast and with all accessories, lights, etc, off, set VR1 so that the top green LED lights at a measured 14.4V.
(2) Now stop the engine and switch on the lights. Wait until the battery falls to a measured 12V and set VR2 so that the lower green LED lights.
(3) Again, the adjustments will affect one another to a small extent so you may need to recheck the results at either end of the scale.

Adjusting the dimming

Turn the dimmer sensitivity trimpot (VR3) until the display dimming matches your preferences– clockwise will give a brighter display at night (so you need to fully cover the LDR to simulate night when you're setting it!). Note that when installing the Voltage Monitor, the LDR must be exposed to the ambient light in order for the display to dim. The LDR can be mounted off the PC board if necessary.

Note

In some cars, this Voltage Monitor will not work on some sensors. For an oxygen sensor, it needs a signal voltage from 0-1V, with the higher voltages corresponding to richer mixtures. The vast majority of cars produced over the last 15 years use this type of sensor but there are exceptions, so be sure to use your digital multimeter to check the oxygen sensor output signal before buying a kit.

For other sensors, the output signal needs to vary in voltage. However, some airflow meters have a variable-frequency output signal and the Voltage Monitor will not work with that type of airflow meter. Again, check the output of the load sensor with a digital multimeter first.

Also note that some modern cars run stoichiometric air/fuel ratios all the time so the rich and lean indications under acceleration and engine overrun may not be apparent on the display. **SC**

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- Single module High-Speed Digital Input / Output solution.
- Integrated Type-B USB Connector.
- On-board unique serial number in EEPROM and custom programmable FLASH microcontroller.
- Both USB Enumeration information and Micro controller can be re-programmed.
- Module powered by the USB from the PC (default option) and can also be configured for Self powered.
- Virtual COM Port driver allows access as a regular serial port.

Great range of I/O-24 peripherals, too ...

OPTO INPUT BOARD
Provides 8 Opto Isolated inputs for each of the I/O-24 pins with LED indication.
RELAY OUTPUT BOARD
Provides 8 isolated relay contact outputs suitable for a variety of loads.
SWITCH/PUSH BUTTON BOARD
Provides 8 switch/push buttons with LED indicators showing the status of the I/O pin.
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Provides screw terminal connections plus optional either pull up or pull down resistors and LED port status indication.
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Our website is BURSTING with bargains!

Purchase directly from our on-line store and you could save up to 50% on hundreds of products throughout the range!
HURRY, THIS SALE MUST END MAY 31st

FREE GIFT!

FOR THE FIRST 1000 IN-STORE CUSTOMERS THIS MONTH!
Stylish, solar powered desk top calculator, **ABSOLUTELY FREE** with any purchase from our Sydney or Melbourne stores.
Valid for in-store customers only.
Strictly limited to one per person.

"Easy-Install" Video Door Intercom

Check who's at the door before opening it.
NEW MODEL! EASY INSTALL!

SAVE UP TO $50!

A safe and easy way to monitor your front door day or night! When the call button is pushed the base station will show live video of your visitor and allow them to speak with you directly. Includes weatherproof camera housing for mounting in exposed areas. Coupled with a S 5385 door strike ($47.20) & M 9274 power supply ($21.95) you can even remotely unlatch your front door/gate to let visitors in.

$159 S 9412 B&W RRP $179
$329 S 9417 Col. RRP $379

Simple two wire system installs in just a couple of hours! No expertise required!

Great for counting tiny components.

High accuracy pocket scales

Designed for measuring and counting lightweight items. Measures in grams, ounces, troy ounces & pennyweight. 0.1g resolution. 500g max weight. **These sell for up to $150 elsewhere!**

$65 T 2260 RRP $89.95

NiMH SUPER SELLOUT!

Good for up to a 1000 recharges! Recoup the cost of these high capacity C (3.5Ah) & D (7Ah) cells batteries in just a few uses.

SAVE UP TO 35%!

4 for $30 S 4748A C Cell RRP $12.50ea
4 for $50 S 4753A D Cell RRP $22.95ea

Reliable Mains Power Anywhere, Anytime!

$55 M 8072 150W RRP $62.95
$89 M 8076 300W RRP $99.95
$179 M 8084 600W RRP $249

Ideal for powering portable appliances on the road. These compact inverters allow you to get mains power from your car or 4wd's 12V battery! Great for camping, farmers, mobile trades people, handypersons etc. Suitable for use with laptops, portable TV's, battery chargers, stereos etc. The 300W & 600W models are also great for small power tools such as drills, angle grinders and more! • Modified sine wave • Host of protection features • Soft start • High/low voltage shutdown • High surge wattage rating

"WALKIE TALKIE" 40 ch. UHF Radio BARGAIN!

UNDER $20 EACH!

No licence required! Perfect handheld radio for recreation, building sites, 4WDs, hikers, campers etc. Features:
• Backlit LCD • Channel scan • Call tone • Battery indicator • Dual channel monitor • VOX • Repeater mode.
4 pack of AA batteries to suit $2.85 (S 4955). Sold individually.
HEAPS OF ACCESSORIES AVAILABLE!

$39pr X 0510 HOT PRICE!

70W "Go-Anywhere" Soldering Iron

$34.80 T 2595S BARGAIN!

FREE 200gm roll of pro quality resin core solder! Valued at $6.90. T 1110

Portable! Easy to use! Don't fumble around in tight spots with a mains soldering iron, this tiny yet powerful gas iron will do the job in a jiffy! Great for auto-electricians or home handypersons. T 2450 250ml butane $4.95.

Mini Keyring JET Blowtorch

Produces a powerful jet like flame! Great for camping, hiking or even as a cigar lighter!
• adjustable flame • refillable gas chamber • one click ignition • sturdy metal case • 12 month warranty.

$15.95 T 2488S BARGAIN!

FREE 250ml can of high grade butane. Valued at $4.95. T 2450

AMAZING INSPECT-A-GADGET!

Illuminated Magnifier
NO MORE EYE STRAIN!

THOUSANDS SOLD!

Let "gadget" be your eyes! Identify those impossible to read miniature components, without straining your eyes. Great for stamp & coin collectors, model makers, seamstresses, jewellers etc.

$99 A 0970A 3 dioptre RRP $109
$109 A 0971 5 dioptre RRP $129

Features an ultra-bright Philips® triphosphor fluorescent tube for extra crisp, clear view!

Cat5e Boxes!

Handy 100m size boxes, ideal for networking the home or business. Also great for custom patch leads. **W 2759** blue

$50 per box RRP $90

NETWORK THE ENTIRE HOUSE!

Bargain 19" Rack Cases

WHOOPS!
Discounted due to small imperfections in the front panel surface. ***Otherwise they're fine!*** Great for test equipment, amplifiers etc. Aluminium front (silver) and rear (black) panels. 2 unit size only.
HURRY, THESE WILL SELL OUT QUICKLY!

$40 HX5012 RRP $65

Super comfortable headset SAVE 20%

3.5 or 6.35mm connection. Equipped with a high performance dynamic microphone. Comfortable ear pads & adjustable headband.

$29 C 90568 RRP $36.50

Test LAN cables *FAST!*

This ultra compact LAN tester will ensure you never have a faulty cable on your network ever again! Instantly displays the status of all cable conductors (shorted pins, straight or crossover cable identification). Suits most common network configurations.

$40 D 3006 RRP $49.95

SAVE OVER 15%

ALTRONICS ONE-STOP ELECTRONICS SHOP

3 Big Electronics Super-stores!

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Order Hotline 1300 797 007

Save Up To 25% On Audio Gear

Replace up to 16 remote controls with just ONE!

With stunning blue backlit LCD screen!

Coffee table covered in remotes again? Tired of juggling a handful of remotes just to watch a movie? The A 0990 combines the functions of up to 16 of your current remotes into one! Easy to set up for your system with easy pre-programmed codes or infra-red learning function. **A high spec remote control for the any home theatre system.**

$99 A 0990 RRP $169

Feature Packed DJ Mixer

SAVE 25%

Excellent value for money! This rugged unit has many features you would expect to find on *"top end"* mixers costing up to 4 times the price! Great for beginner DJ's looking for an entry level mixer at a great price.

Features: • 3 band EQ (+20dB boost / -30dB kill) • Super smooth cross fader • Invert switch • Crossfader curve adjustment • Full band kill switches • Transform function • M 9253 plugpack to suit $19.50

$150 A 2546 RRP $199

Waterproof 4" outdoor speakers

Employs an all weather speaker and grill assembly, ensuring long life even in salty marine or tropical environments. A maintenance free way to have great sound outdoors, all year round. Very easy to install! 20W RMS. 4Ω.

Ideal for boats, yachts, outdoor entertaining areas etc.

$79/pr C 0840 RRP $99

Power up to 8 speakers from a single amplifier!

This compact box allows you to run up to 4 pairs of speakers from a normal stereo amplifier. Distributed audio in homes is now becoming very popular and is a great way to extend your lounge stereo system into a games room or entertainment area. 150W power handling.

$129 A 2370S BARGAIN!

FREE 50m roll of pro quality oxygen free WHOPPER WIRE. Valued at $60! W 2140

Transmit audio & video in your home

The easy cable-free way to transmit audio and video. Sends clear vision and hi-fi sound to another location and even lets you control your audio equipment remotely.

$79 S 9360A RRP $94.95

Why buy 2 satellite/digital decoder boxes? Transmit it from your lounge room to anywhere in the house!

FM Transmitter for MP3 players

NEW!

$26.95 X 0600 BARGAIN!

Transmits audio from your MP3 player to your car radio. Car accessory socket power adaptor included (also runs off 2 x AAA's). Easy to set up and use. 4 channels 88.3-88.7MHz FM band.

Build your own subwoofer

Enhance your sound system! Add mindblowing realism to your favourite video or DVD! Turn your lounge room into a cinema with your very own custom subwoofer. Module is fantastic for building into custom subwoofer cabinets. Equipped with volume, crossover frequency control, phase switch, high and low level outputs. 120W RMS. Stable into 4 ohms.

$150 A 2451 RRP $179

PACKAGE DEAL For just $200 you receive: 1 x A 2451 120W module, 2 x C 3088 8" high spec woofers, Valued at $297. SAVE $97! Sounds great in bass reflex or band pass enclosures. (A 2451S)

Great Savings On Power Equipment

Keep your car or boat battery charged.

$30 N 0700 RRP $33

Tired of forking out $100+ for batteries when you leave your car or boat sitting for a few weeks? This solar charger keeps your battery in top condition, even over long periods of inactivity. ≈100mA charge rate. Connects via car accessory socket or croc clips. 335 x 125mm panel size. *Will not charge dead flat batteries.

Keep the boat battery topped up over the winter break!

POWER SUPPLY FOR LIFE!

HUGE SAVINGS!

Fully adjustable with LCD meters for precision adjustments. Great for R&D, workshops or repair centres etc. • Separate controls for voltage and current • Fixed 12V & 5V output rails • Precision LCD voltage & current meters • 0-30V adjustable • Fully regulated • Short circuit & overload protection

$185 M 8200A 3A RRP $239

$235 M 8205 5A RRP $299

DATALOGGING RS232 METER

A superb meter featuring optically isolated RS232 connection and software for WELL UNDER $100! Great for analysing battery chargers, timed circuits or many other variables! Features: • DCV to 1000V • ACV to 750V • DC A to 10A • Resistance to 40MΩ • Capacitance to 100µf • Continuity • Frequency • Duty cycle • Diode test • Auto power off • Data hold

Software allows datalogging with variable sampling time, data storage, plus graph output!

$85 Q 1078 RRP $99

30 Range LCR METER

PROFESSIONAL QUALITY

Without a doubt one of the finest multimeters we have ever sourced! Exceptional performance and features for your dollar. Perfectly suited to the engineer or electronics trades person. **Features:** • 10Mhz frequency counter • Capacitance • Inductance • Resistance • Peak & data hold • AC/DC current to 10A • Auto power off

$110 Q 1084 RRP $159

SAVE 30%!

6 Amp Solar Charge Controller

Great for portable power systems on 4WDs, caravans etc. Suits wet or dry cell batteries. 6A charging current. Dipped in an epoxy resin allowing it to be utilised in damp or humid areas.

$33 N 2075 RRP $39

High current 70A DC breaker

Great for use on solar power systems in 4WD's etc. Protects equipment in the event of a short circuit.

$20 C 9750 RRP $24.95

SLA Battery Charger

Compact, easy to use with trickle charging function. Suits 12V SLA batteries up to 7.2Ah. 300mA charge current.

$19 M 8520 RRP $24.95

Save up to 20% on Sealed Lead Acid Batteries

Premium quality for long life.

Great for security, solar power systems, UPS, comms gear etc. All are 12V output.

	Rating	Normally	Now
S 5080	3.3Ah	$24.95	$20
S 5090B	7.2Ah	$36.50	$28
S 5098	12Ah	$42	$35
S 5100	20Ah	$49	$40
S 5104	26Ah	$65	$50
S 5113	40Ah	$105	$89

Autoranging Multimeter

With 1300°C temp probe & capacitance function. Perfect for technicians, installers & enthusiasts who require a wide range of functions & value for money. **Features:** • Range/data hold • AC/DC volts • Capacitance • Resistance • Transistor/diode check • Temperature

$40 Q 1132 RRP $49.95

Great value for the hobbyist or enthusiast! SAVE 20%

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More Great Bargains...

Long Life LED Lighting...

LED "halogen type" globe
Replace halogens with efficient, low heat LED globes. Great for motorhome, caravan and boat lighting. Also ideallly suited for feature & cabinet lighting around the home. For 12V DC power applications. 1W light output.

$30/pr
X 2150 MR16 12VDC
RRP $19.95ea

High Power 3W LED lights
Direct replacement for MR-16 halogen globes. Provides up to 100,000 hours of life, much more than ordinary halogens. Perfect for caravans and boats. Powered off a standard halogen transformer (please note: switch-mode transformers may require up to 4 LED lights per circuit to operate correctly) . 3W light output, 5W power consumption. 12-24V AC/DC operation

$60/pr
X 2200A Cool White
X 2206A Warm White
RRP $45ea

Low voltage (12V), high intesity LED globes **Long life 100,000 hour LEDs**
Replace your regular auto globes with these long life LED versions. Available in single or dual intesity types. 15mm bayonet fittings.

$26/pr
X 2300 Single Intens.
X 2306 Dual Intensity
RRP $16.95ea

Protect your family, possessions and home today!

SAVE 20% THIS MONTH ONLY!

6 Sector Home / Business Alarm System
At last a quality professional alarm system at an affordable price! Install it yourself and save a fortune! Protect your home over the holiday season! It is supplied in 2 parts (main unit & keypad) and can be fully installed and programmed by **YOU** in just hours. It's just that easy! Its inbuilt dialler function can ring up to 4 different phone numbers when your alarm triggers. M 9332 16V AC plugpack to suit $23.50.

$320
S 5264
RRP $399

BARGAIN Passive Infra Red Sensors
WHOOPS, CUSTOMER CANCELS ORDER!
Pick up a bargain with these custom PIR detectors suitable for security systems. They feature a buffered transistor output & can be configured with a relay if required. Connection instructions provided.

$15
SX5306
BARGAIN!

OR BUY 4 FOR $50!

Security Discounts

BARGAIN B&W DOME CAM!
Super quality picture!

Utilises a high quality CCD sensor for an excellent, low noise picture. This compact dome camera easily mounts to ceilings, under eaves etc. Camera angle can be quickly adjusted as required. M 9243 plugpack to suit $18

$65
S 9112A
RRP $85

BNC Video Leads
1.5m length.
Ideal as patch leads from a DVR to monitors or cameras etc.

3 for $15
P 6336
RRP $7.95

20m Camera Extension Lead
Extends audio (RCA), video (BNC) and DC (2.1mm) power connections. All in one cabling solution

SAVE OVER 30%

$20
P 6713
RRP $29

Premium Project Components

High Power Star LEDs
SUPER BRIGHT 1 WATT OUTPUT!
High power LEDs fantastic for use in low voltage lighting. Very little heat generation compared to incandescent lights. **Build a high power LED power supply kit to suit, K 1010 $29.95.**

$12.50
Z 0247-53
RRP $13.95

Great for caravan, effects & feature lighting

Z 0247 Red
Z 0248 Green
Z 0250 Orange
Z 0251 White
Z 0252 Warm White
Z 0253 Blue
Z 0261 Warm White with lens

$16.50
Z 0261
RRP $19.95

25% OFF!

Blank PCB
Single sided blank PCB.
300 x 300mm size. Make your own PCB's and save!
Add some etchant to your order for $12.55 (H0802).

$15
H 0755
RRP $19.95

Waterproof Float Switches
Perfect for water tank systems such as rain or waste water management, activating boat bilge pumps etc. Fully immersible. Can be used to activate pumps or electric valves when liquid levels change. 200V 0.5A

$25
S 1160 Horiz.
RRP $29.95

$15
S 1163 Vert.
RRP $19.95

DISCOUNT PANEL METERS!
Selected models slashed to clear!
Q 0525: 0-30V MU45
Q 0523: 0-20V MU45
Q 0515: 0-10A MU45
Q 0500: 0-0.1mA MU45

$12ea
ALL MODELS
RRP $17.95

Limited stocks at this fantastic price!

Alphanumeric Display
16 characters, 2 lines. Great value for money! Easy to integrate into most designs. Memory contains 196 characters!

$19
Z 7001
RRP $22.95

High current 30A DC Connectors
Designed for automotive and industrial applications. Clip together to form multipole connectors for wiring looms.

$2.50ea
P 7806 Blk
P 7805 Red
HOT PRICE!

Replace that noisy old fan!
Quality replacement SUNON® fans. All 12V with sleeve or maglev bearing construction.

SAVE UP TO 33%

SUNON Fans	RRP	Now
F 0010 40mm Maglev	$8.95	$6
F 1045 60mm Sleeve	$16.75	$13
F 1050 80mm Sleeve	$16.75	$13
F 1065 120mm Sleeve	$28.90	$22

CLEAROUT Relay BARGAIN!

$20/10pk
SA4198
RRP $5ea

16A SPST 12V PCB Relay. Great for high current applications, experiments, new designs & projects.

OVER 50% OFF HEATSINKS!

4 for $10
H 0560A
RRP $5.95ea

110W x 33H x 43L.
Great for power supplys, amplifiers etc.

Sturdy panel mount fuse holders
3AG type. Rated at 10A @ 250VAC max. Packs of 10.
SAVE OVER 60%!

$5/10pk
S 6000
RRP $1.30ea

Powertran® Toroidal Trannies
HALF PRICE!

All models come with 15V auxilliary windings in addition to secondaries. Manufacturer quality!
HURRY STOCKS ARE LIMITED!

Toroidals	RRP	Now
MB5330 160VA 30+30V	$55	$27.50
MB5337 160VA 37+37V	$55	$27.50
MB5530 300VA 30+30V	$80	$40
MB5335 300VA 35+35V	$80	$40
MB5340 300VA 40+40V	$80	$40
MB5345 300VA 45+45V	$80	$40
MB5340 500VA 45+45V	$120	$60
MB5345 500VA 55+55V	$120	$60

BARGAIN Plugpacks
9V 300mA. Tip positive.
60% OFF THIS MONTH ONLY!

$5ea
MA9236
RRP $12.95

BOPLA® Weatherproof Enclosure
LIMITED QUANTITY! Altronic's have picked up a bunch of these famous German made BOPLA®, shock resistant control boxes. These can sell for up to $80 at some suppliers! Great for pool or retic, industrial equipment, garden lighting, circuitbreakers etc. IP65 rated. 130 x 212 x 257mm
Limit 2 per customer.

$10ea
HX0002
RRP $20

BARGAIN!

Gaffa Tape JUMBO 40m ROLL!
Tough, sticky fibre tape for holding just about anything together!

$20
T 2960
RRP $27.95

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No Risk 14 Day Money Back Guarantee

If you are dissatisfied with our goods for any reason, return to our premises within 14 days for a full refund (less transport costs). Returned items must be in NEW condition with all packaging and instructions (less transport costs).

Over 150 useful projects in stock

Silicon Chip Studio Series Pre-Amp Modules

Pre-Amp Input Module

Utilising the latest ultra low noise high peformance op amps. Featuring 5 RCA inputs plus easy integration with the headphone amplifier & power supply module. **Unbelievably low 0.0005% distortion!** Supplied with PCB, components, input rotary switch, volume pot & cabling.

$54.95 K 5502 NEW KIT!

Power Supply Module

A low noise linear power supply module to suit the Silicon Chip Studio Series Pre Amp. Easy to build and integrate into your pre amp project!

$15.95 K 5501 NEW KIT!

ATTENTION AUDIOPHILES: The studio pre-amp provides as good as Class-A performance! Superb audio quality for an affordable price.

Headphone Amplifier Kit

Ultra low noise, low distortion design. Drives high and low impedance headphones. Great for those requiring a bit more listening "oomph" from their portable MP3 player or CD player. Features dual headphone outputs.

$29.95 K 5503 NEW KIT!

Remote Control Volume Module

Add the latest module to your studio pre amp project. This board allows volume adjustment and input switching via infra red remote.

$59 K 5504 NEW KIT!

SAVE OVER 20%!

Build your own bench power supply!

$119 K 3250 RRP $149.95

(SC July. '2000) Perfect for testing projects or charging batteries, this is a must have for any workshop Variable from 1.23-40V, at up to 1A. Features a precision LCD panel meter. With variable current limiting. *Kit supplied with professional punched & screened metal case, premium components & silk screened PCB for easy assembly.*

Monitor your 240V power usage

Find out what its REALLY costing you to run your appliances! **(SC July 04)** This energy meter allows you to keep a keen eye on every electron you use! It simply connects inline with your appliances and provides usage figures in both kilowatt hours (kWh) or dollars. Great way to budget energy within the home or business and reduce operating costs!

$110 K 4600 RRP $129.95

With added "brown-out" protection for your appliances!

Remote Control Light Dimmer

PLUS touch plate for activating and adjusting lights. Remote control lighting adds a touch of class and convenience to your home. Remote to suit A 1009, $35. **Features:** • Adjustable dimming • 12V DC powered • Soft start for long globe life • Touch plate or remote control operation • Aluminium wallplate.

$55 K 6030 RRP $69.95

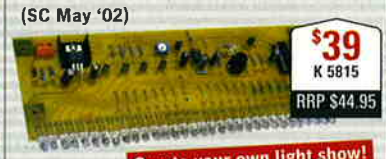
VoIP Adaptor Kit

Attach your normal home phone to your PC and make cheap VoIP phone calls! Save a fortune on your phone bill by making calls to your family and friends via your broadband internet. Easy to build! *battery not included

$22.95 K 2780 NEW KIT!

Turn your car into "Knight Rider"

(SC May '02)



Create your own light show!

Incredibly easy to build, this cool LED chaser has 32 superbright red LED's that can light up in 12 different patterns. Powered by 12V DC.

$39 K 5815 RRP $44.95

12V SLA Battery Charger

(SC Mar 03) Feeds your batteries with pure DC power until charged & will disconnect from the battery when power is removed. 7.2Ah max. Plugpack to suit M 9325 ($21.50).

$16 K 1695 RRP $19.95

$45 K 9050 RRP $54.95

Trigger alarms, lights and appliances via SMS

(SC October 04) Great idea for home or car security, in addition to literally THOUSANDS of home automation possibilities! Coupled with an old mobile phone, this module provides automated triggering of contacts via SMS. It can also SMS you and provide status updates!

Get status updates on computers, security systems and other essential equipment ANYWHERE IN THE WORLD!

Improve the flash performance of your digital camera

A low-cost way to take professional flash photos

(SC July 03) Digital Slave Flash Trigger Kit

Allows any digital camera with a flash to trigger a larger external flash unit. Using an external flash can often improve photo quality dramatically! Can be built for a fraction of the cost of similar 'smart-trigger' units. 9V battery powered

$20 K 8080 RRP $29.95

Audio Signal Generator

SAVE 35%

(SC Feb '99) A low distortion wide frequency audio oscillator. A must for testing audio projects at a fraction of the cost of commercial units.

Features: • Float/ground switch • 10Hz - 100kHz in 4 ranges • Low distortion and noise levels • Output 3.16Vrms sine wave max, 3.16 V peak square wave • Square wave rise and fall typically 33ns • Frequency readout resolution 10% of selected range • High frequency accuracy • Output impedance 600Ω • Sync output • High slew rate.

$149 K 2548 RRP $229

Sale ends May 31st 2006

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QLD	
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Prices stated herein are only valid for the current month or until stocks run out. All prices include GST and exclude freight and insurance. See latest catalogue for freight rates.

PICAXE Goes Wireless

Pt.2: By CLIVE SEAGER*

* Clive Seager is Technical Director of Revolution Education Ltd, the developers of the PICAXE system.

Get your PICAXE projects talking over the airwaves using the latest high-tech 2.4GHz XBee modules!

IN PART 1 LAST MONTH, we described how to build and test a pair of wireless data communications nodes based on AXE210 project boards and XBee modules from MaxStream. This month, we look at some of the more advanced features of the XBee modules.

By way of example, we then learn about some of these features during the construction of a wireless light and temperature sensor, based on one of the AXE210 boards. As part of the project, we also see how to receive and log the data from the wireless sensor to disk with the aid of the second AXE210 board and a PC.

Finally, we dispense with the PC altogether and see how easy it is to get a PICAXE-to-PICAXE wireless link up and running!

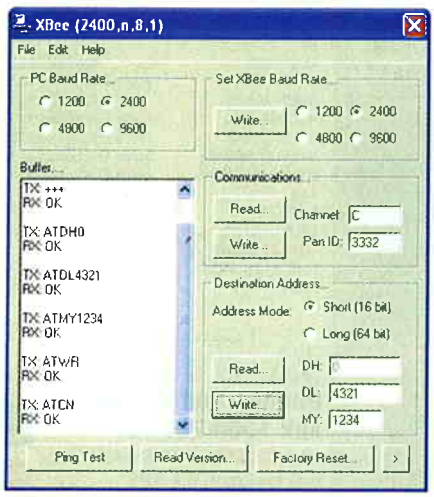


Fig.1: here's a screen shot of the XBee Setup wizard, showing the correct settings for board #1. Remember to swap the DL and MY values around when programming board #2!

XBee networking

As demonstrated last month, sending and receiving data between two XBee modules is quite straightforward. In those examples, we relied on the XBee's default settings.

However, consider the case where more than one module is within receiving range. Unless we specifically want to send a "broadcast" message to all modules, then some means of addressing the data to the intended recipient is required.

This is where the XBee's intelligent networking features come into play. For a start, each module is factory programmed with a unique serial number, allowing it to be explicitly addressed. In addition, each XBee module can be identified with a programmable "nickname" for ease of use.

Other powerful networking features include the ability to arrange modules into groups, or "private area networks" (PANs). By assigning a common group ID to all members, modules not part of that group are automatically excluded.

So how do you set an XBee module's nickname or group ID? Well for modules connected to a PC, it's quite straightforward; you'd use the Programming Editor's "XBee Setup" wizard. We'll investigate this method in more detail shortly.

You can also set these parameters using a microcontroller such as our PICAXE-18X. Although we don't cover this method here, it's simply a matter of sending the appropriate commands to the XBee module before sending or receiving data over the radio link.

To do this, the module is first placed in command mode by sending a special sequence of characters. Once in command mode, the command(s) and any other parameters (such as the nickname mentioned earlier) are sent. A final "exit" command returns the module to idle mode, ready to send and/or received data over the airwaves.

Table 1: Module Settings

Parameter	Board #1	Board #2
Baud rate <BD>	2400	2400
Broadcast channel <CH>	C	C
Network group <ID>	3332	3332
Destination nickname <DL>	4321	1234
My nickname <MY>	1234	4321

Before continuing, we strongly recommend that you download and review the XBee datasheet, available from **www.maxstream.net**. There you will find a detailed description of the XBee's networking features and the various commands needed to make them work.

In the following project examples, we'll refer to a subset of the XBee's commands and their related terms. An informative summary of these is given in Table 2.

Putting it into practice

If all the addressing information sounds a bit confusing, don't worry – it should become clearer with a couple of examples! In this first of these, we will wire up a temperature sensor and a light dependent resistor (LDR) to the PICAXE chip on one of the AXE210 Connect boards. We'll then transmit data gathered from the sensors via the on-board XBee module to a second XBee module connected to a computer, where is can be viewed on-screen or logged to disk.

This example uses "nickname" (short) addressing. We've arbitrarily chosen address "1234" for board #1 and "4321" for board #2, so let's begin by programming these addresses into the two XBee modules.

Initially, we'll configure both boards for "PC to XBee interface" use (mode #2), as described last month. To do this, insert the MAX3232 chip into its 16-pin socket on each AXE210 Connect board (remove any PICAXE chip) and make sure jumper J1 is in the "top" position).

Next, start the PICAXE Programming Editor and open the "XBee Setup" window by selecting *PICAXE -> Wizards -> AXE210 PICAXE Connect* from the toolbar. The settings required for each module are shown in Table 1.

As you can see, all of the settings are the same, apart from the "my nickname" and "destination nickname" values, which have been swapped. This allows the two modules to correctly identify each other. Fig.1 shows a screen shot of the settings for the XBee module in board #1; remember to swap the DL and MY values around when programming board #2!

After altering any parameter, note that the associated "Write" button must be clicked otherwise your changes

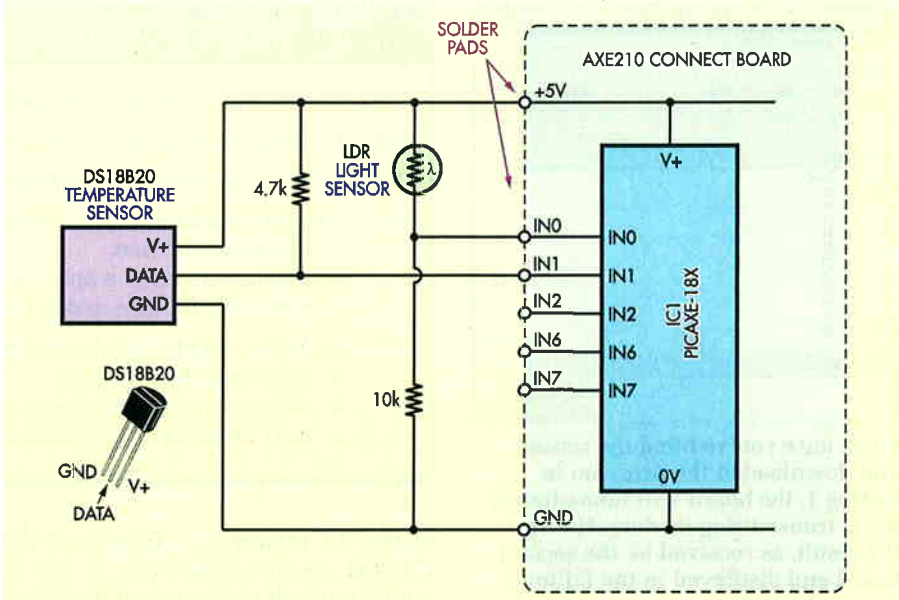


Fig.2: light and temperature sensors are wired to board #1 for the first project. This simplified circuit shows the connections, made via the row of solder pads next to the serial socket.

Table 2: Introduction To XBee Buzzwords

Broadcast Channel <CH>
XBee modules can communicate on 16 different "broadcast channels". All XBee modules in the same network must share the same channel number. Different channels can be used for different networks for privacy reasons or to reduce interference. In addition, switching channels can sometimes be an effective means of reducing interference from competing transmitters, such as computer WiFi networks, microwave ovens and cordless telephones.

Baud Rate <BD>
This is the data rate on the XBee serial interface (ie, between the XBee and PICAXE or computer). When using a PICAXE micro, choose a baud rate of 2400 for maximum compatibility. Although slow by modern standards, this rate is adequate for most projects.

Network Group <ID>
XBee modules can be arranged in network groups (also called "Personal Area Networks", or "PANs"). Each module will only respond to others in its group, as defined by a 16-bit ID number.

Serial Number <SH> <SL>
Each XBee module has a unique, factory-assigned 64-bit serial number (also called a "long address"). The serial number is printed on the bottom of the module and obviously cannot be changed. Data can be addressed to a specific device by including its 64-bit serial number.

Nickname <MY>
Optionally, an XBee module can be addressed by its "nickname" (also called a "short address") rather than by serial number. Nicknames have the advantage of being user-programmable and are only 16-bits long – so they consume less memory in a PICAXE. Using this method of addressing, any module in a network can be replaced with a new unit (which would have a different serial number) simply by programming it with the existing nickname.

Fig.3: once you've fitted the sensors and downloaded the program in Listing 1, the board will immediately begin transmitting its data. Here's the result, as received by the second board and displayed in the Editor's terminal window.

Fig.4: data gathered from the sensors can be saved to disk with this excellent freeware RS232 logging program from Eltima. Be sure to alter the serial port options to suit the PICAXE system.

will not be saved. Once you've configured both boards, it's a good idea to perform a ping test to verify that the units are in fact communicating. Details of how to do this test were given in last month's article.

Light & temperature sensor

We've chosen board #1 to operate as the remote temperature and light-sensing node, so remove the MAX3232 chip and plug the PICAXE-18X into its 18-pin socket. This is the "PICAXE to XBee interface" configuration (mode #1) described last month.

Next, wire a light-dependent resistor (LDR) and DS18B20 temperature sensor to *input0* and *input7* of the PICAXE, as shown in Fig.2. A row of solder pads along the top of the board provides easy access to the port input pins, as well as +5V and ground.

As the circuit is extremely simple, it could be wired "point-to-point" with light gauge hook-up wire. Alternatively, you could use a small solderless breadboard for the job; see Pt.3 of the "PICAXE in Schools" series, published in July 2005 for ideas on breadboard use.

Now connect board #1 to your computer and download the program shown in Listing 1 into the PICAXE chip. The "init" section of the program sets the serial pin high and then waits for 100ms. This gives the XBee time to wake up. The main loop then reads the light value (**readadc** on *input0*) and temperature value (**readtemp** on *input1*) and transmits the data every second.

Disconnect board #1 from the computer and connect board #2 (fitted with a MAX3232). The data being transmitted by board #1 should now be displayed in two columns in the Terminal window (see Fig.3) – it's that simple!

Logging data

PICAXE users often ask for serial datalogging software to allow readings from a project like this to be stored in a computer file, so that the data can be analysed later. Our favourite piece of software to do this is "RS232 Data Logger" from Eltima Software (**www.eltima.com**), as it's free and very easy to use.

To use the RS232 Data Logger, just highlight the COM port of interest, enter the filename and select the appropriate serial port options (see Fig.4). All you then need to do is click on the "Start logging" button!

Once the logging is complete, click on the "Stop logging" button. The file created can then be opened in Excel and many other applications, depending on your requirements.

Light and temperature warning

This second project demonstrates wireless PICAXE-to-PICAXE communication. Board #1 remains unchanged, while board #2 must be fitted with a PICAXE chip and two LEDs. These will be used to indicate the state of the temperature and light readings received from board #1.

Begin by fitting the PICAXE chip to board #2 (don't forget to remove the MAX3232!). The two LEDs are connected to *output0* and *output1* of the PICAXE, as shown in Fig.5. A row of solder pads along the bottom of the board provides easy access to the port output pins and ground.

That done, connect board #1 to your computer and download the new program shown in Listing 2. As you can see, we no longer have the "#" character before the variable names, because we are now transmitting raw byte data, rather than ASCII characters. Two "$55" characters also precede each transmission; this is a simple means of ensuring that the receiver accepts only valid data.

Now connect board #2 to your computer and download the receiving program in Listing 3. This program waits for valid data from the transmitter and then switches the LEDs according to the predefined temperature and light threshold values.

Initially, the **debug** command can

XBee Communications Checklist

(1) All modules must use the same baud rate (recommended).

(2) All modules must be on the same broadcast channel.

(3) All modules must be in the same network group.

(4) An XBee module can be configured to transmit to:
- any other module,
- a module(s) with a specific nickname, or
- a specific module, using its 64-bit serial number.

(5) An XBee module can be configured to receive data:
- from any other module,
- only when its nickname is used, or
- only when its 64-bit serial number is used.

Parts List For Project Examples

1 DS18B20 digital temperature sensor
1 light-dependent resistor (LDR)
2 3mm or 5mm LEDs
light-duty hook-up wire

Resistors (0.25W 5%)
1 10kΩ 2 330Ω
1 4.7kΩ

The temperature sensor (Part No. DS18B20) and LDR (Part No. SEN002) are available from Micro-Zed Computers, phone 1300 735 420 or browse to **www.microzed.com.au**.

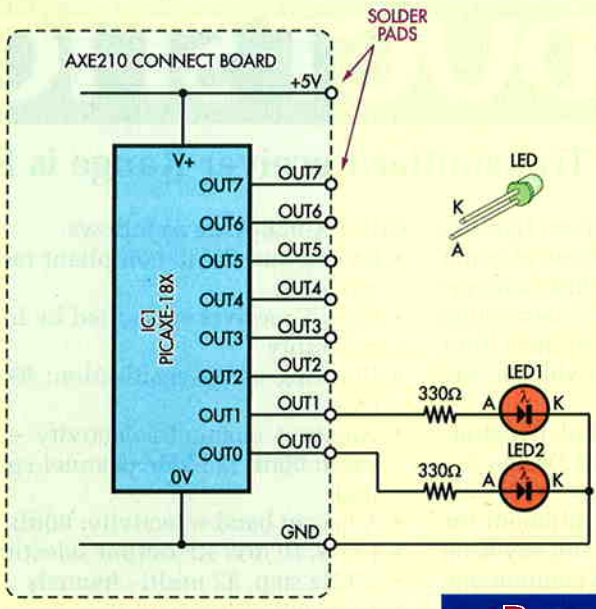


Fig.5: two LEDs and their current limiting resistors are connected to board #2 for the second project. The connections are made via the row of solder pads situated between the two reset switches.

be used to display the received values on-screen. As shown, the program uses "40" as the light threshold value and "20" as the temperature threshold. You may need to tweak these slightly, depending on your ambient conditions.

Reducing power consumption

If you are designing your own project based on the AXE210, you are likely to be considering batteries as the power source. Two simple improvements to the project board are immediately obvious. The first is to power the whole circuit from a 3V battery pack, allowing you to bypass the two relatively inefficient voltage regulators.

Of course, you'll need to disable the two voltage divider circuits on *output6* & *output7* when the PICAXE is running on the lower 3V supply. If you've already built the boards, then the easiest way to achieve this is to remove one 10kΩ resistor (the one connected to 0V) from each divider string.

You can also use the "sleep" function of the XBee module to reduce power consumption. By installing jumper J4 on the board, the SLEEP pin of the XBee module is connected to *output6* of the PICAXE chip. This then allows you to place the XBee module in low-power sleep mode with a **low** command and wake it up when needed with a **high** command.

Note that to allow the XBee module to enter low power mode using the external SLEEP input, you must first configure it to do so via the advanced settings in the XBee Setup wizard. Click the ">" button to see the advanced settings.

You'll note that two pin-controlled options are available under the "Set Sleep Mode" heading – "Pin Doze" and "Pin Hibernate". The difference between these two options is summarised as follows:

Option	Current Drain	Wakeup Time
Pin Doze	<50µA	2ms
Pin Hibernate	<10µA	13.2ms

Increasing range

Need more range? A higher-powered version of the XBee module called the "XBee Pro" is also available. It boasts a transmit power of 100mW, versus the 1mW of the standard XBee. The two modules are pin-for-pin compatible, so no changes are required to the AXE210 board to use the uprated module.

But before spending more money on the "Pro" module, check out Stan Swan's 2.4GHz gain antennas in this issue. They cost virtually nothing, are fun to build and can increase range by two times or more!

Summary

The XBee modules make serial communication between PICAXE projects a breeze. Additionally, their range can be increased significantly for little cost using home-brew antennas. For more information on the XBee modules, point your browser to **www.maxstream.net** SC

Program Listings

Listing 1

```
symbol TAB = 9

init:
  high 7
  pause 100
  serout 7, T2400, ("Light",TAB,"Temp",CR,LF)

main:
  readadc 0,b0
  readtemp 1,b1
  serout 7, T2400, ( #b0,TAB,#b1,CR,LF)
  pause 1000
  goto main
```

Listing 2

```
init:
  high 7
  pause 100

main:
  readadc 0,b0
  readtemp 1,b1
  serout 7, T2400, ($55,$55,b0, b1)
  pause 1000
  goto main
```

Listing 3

```
main:
  serin 7, T2400, ($55,$55),b0, b1
  debug

test_LDR:
  if b0 > 40 then LDR_high
  low 0
  goto test_temp

LDR_high:
  high 0

test_temp:
  if b1 > 20 then temp_high
  temp_low    low 1
  goto main

temp_high:
  high 1
  goto main
```

PRODUCT SHOWCASE

Telelink's New Transmitter/Receiver Range is RoHS Compliant

With RoHS (Restriction on Hazardous Substances) rules about to come into effect in Europe, Telelink Communications has introduced a new range of compliant 484MHz equipment from Circuit Design Inc (Japan) which meets the directive.

Jack Chomley of Telelink (Australian distributors of Circuit Design Inc equipment) said that many of his customers were building equipment for the international market and anything incorporating non-RoHS components would not be able to be sold into Europe from now on.

"Many other countries expected to follow suit within the near future," he said. "Manufacturers better get used to the new directive or they'll lose any chance of exporting their products."

The features of CDP-TX-02E-R & CDP-RX-02E-R are as follows.

- R&TTE and RoHS compliant radio modules
- Class 1 receiver supported by high reliability
- Blocking or desensitisation: 84dB (All)
- Adjacent channel selectivity – in band: 60dB (25 kHz channel spacing)
- Adjacent band selectivity: 60dB
- 1 mW/10 mW RF output selection
- 25kHz step, 32 multi-channels
- A transmission circuit structure that is highly resistant to reflection
- Improved shock and vibration resistance
- Uses a custom SAW filter to avoid radio interference from other radio equipment
- High receiver sensitivity using double superheterodyne receiver circuits: -120dBm (12 dB SINAD).

Contact:
Telelink Communications
PO Box 5457, Nth Rockhampton, Qld 4702
Tel: (07) 4934 0413 **Fax:** (07) 4934 0311
Website: telelink.com.au

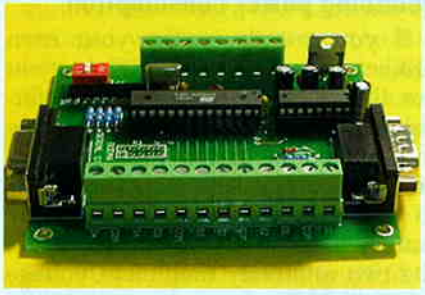
Modbus Programmable Stepper Motor Controller

Based on the Serial Stepper Motor Controller featured in SILICON CHIP July 2005, the introduction of a more powerful microcontroller has allowed Ocean Controls to produce a standalone four-axis stepper motor controller which can be programmed via a PC using supplied windows software or alternatively controlled via a PLC to free the PLC from complex stepper motor control routines. Up to four cards can be controlled from a PLC using the Modbus protocol.

Up to 120 instructions can be programmed into the controller for one motor, 80 instructions for two, 60 instructions for three and 50 instructions for four motors. Instructions are save in EEPROM and are retained through power loss. Just program once and then let it go.

Ideal for repetitive process tasks involving stepper motors, the unit provides eight digital outputs which can be used as the direction and step signals.

The outputs can also be used as general purpose digital outputs when not being used for motor control and the four digital inputs can be used for limit switches or program control.



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Lab & Workshop Gear from DSE

Dick Smith Electronics have shown us some of their new laboratory and workshop gear.

First up are two new professional standard multimeters. These are the highly regarded "Meterman" brand with a large, 2000 count display and not only have the ranges you'd expect to find, they also include a 1.5V and 9V battery checker (with load) , AC current from 200µA to 200mA and a continuity/diode check.

But wait, there's more! There's also "VolTect": a non-contact voltage indicator which buzzes and lights in the presence of AC line voltages.

The 5XP model (left – Cat Q-1786) retails for $78.99 while the higher-performing 30XR model (right – Cat Q-1781) sells for $99.00

Also shown this month is an 18V cordless drill kit. The drill has a variable speed (0 to 900RPM) and a 10mm keyless chuck with 17 Torque settings. Included in the kit is a five hour charger with auto cutoff and various drill/screwdriver bits, all for the very attractive price of just $29.99.

Finally, for those who must undo tamper-proof screws comes this handy

eight-piece security Torx-style keys made from super-hard S2-grade steel alloy. Sizes include T5, T6, T7, T8, T9, T10, T15 and T20 and are supplied in a folding plastic retainer.

Retail price is $12.99 (Cat T-3547).

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Dick Smith Electronics (all stores)
PO Box 500, Regents Park DC NSW 2143.
Tel: 1300 366 644 **Fax:** (02) 9642 9155
Website: www.dse.com.au

100,000 Application Publishing Solutions to be Given Away!

London-based 2X is giving away 100,000 free versions of its application publishing solution, 2X ApplicationServer, in a bid to make application tunneling affordable to all.

With it, companies can seamlessly tunnel any Windows application onto remote desktops, without having to install the application onto each user's machine.

The offer is available from www.2x.com/applicationserver/application-publishing.htm.

The first 100,000 visitors are entitled to a free 5-application license of 2X ApplicationServer for Windows Terminal Services. Organisations can install applications onto one central server and use 2X ApplicationServer to seamlessly tunnel up to five applications per server onto remote desktops.

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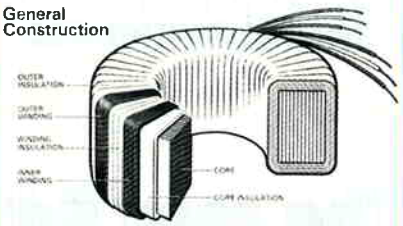

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And the winner is...

The first monthly winner (March 2006) of one of these superb DSE 20MHz dual-channel 'scopes is

Mr Malcolm Amey of Mittagong, NSW

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See P99 of this issue for full details!

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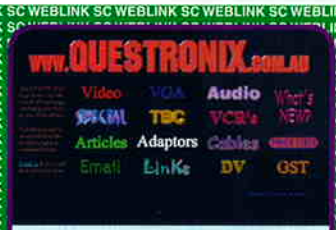

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Vintage Radio

By RODNEY CHAMPNESS, VK3UG

The rare Edison R6 console receiver

Built into an ornate timber cabinet, the Edison R6 console was a high-performance TRF receiver with nine valves. It's quite a rare receiver with some interesting design features.

DESPITE HIS well-known association with the cylinder phonograph, the name "Edison" is not usually associated with radio receivers. Indeed, most people are completely unaware that Edison was ever involved in the manufacture of radio equipment.

Edison's association with radio manufacture came about when his company purchased the Splitdorf Radio Corporation of Newark in New Jersey, USA around 1928. Along with many other manufacturers in the 1920s, Splitdorf had been caught out producing too many radios for a contracting market at the beginning of the depression. As a result, the near-bankrupt company was taken over by Edison to become the Radio Division of Thomas A. Edison Inc.

The RF chassis (top) sits on a shelf, while the audio output/power supply chassis rests on the bottom of the cabinet. Note the retrofitted 240V-to-110V mains transformer at bottom right.

Edison himself was not directly involved in the Radio Division, having apparently delegated that responsibility to his son Theodore. Their venture into radio manufacturing was to be short-lived however, with production ceasing by the end of 1930. Hence, only relatively few sets were produced by Edison and they are now quite rare.

Early history

Protectionism was rife during the Edison era and the importation of radio sets was curtailed by the Australian Government around about 1930. This meant that local manufacturers had an easier time, as they had no effective overseas competition.

However, it also meant that the quality designs from overseas had little influence on the Australian market, except where some licensing arrangement could be reached. This meant that Australians were denied the chance of owning quite a few very good receivers, such as the R6 Edison described in here.

This particular receiver was one of three imported in 1930 by A. R. Harris Company of Christchurch, New Zealand. The fate of the other two is unknown but this one was used by the Harris family for many years before being put up for auction in Christchurch. There has been more horse-trading since then and the set is now part of a collection on the north coast of New South Wales, where I believe it will remain for a long time. It had been quite skilfully restored by a previous owner and the only "modification" is the installation of a 240V-to-115V transformer to the right of the power supply/audio output stages, as viewed from the rear of the set.

Main features

The R6 is built into a timber console

cabinet which is on turned wooden legs. By contrast, its R7 sister receiver is in a lowboy cabinet but shares the same electronics.

The cabinet is quite attractive and would have complemented the decor of the typical 1930s lounge room. It has two doors which are folded out when the receiver is in use. In addition, it features a fancy loudspeaker fretwork cut-out that looks rather like a large 4-leaf clover and sets the speaker section of the cabinet off very nicely.

Immediately above the speaker section is the dial scale and the five controls. These are, from bottom left to right, volume, on/off and tone; and from top left to right, local/distance and tuning. The "Light-O-Matic" is a fancy name for the dial-lamp switch. It is a mechanical switch that illuminates the dial lamp when the set is tuned to a selected station. This switching is accomplished by a contact on the dial drive system.

They certainly had some rather flash names for some of the very ordinary facilities on the radios of the time!

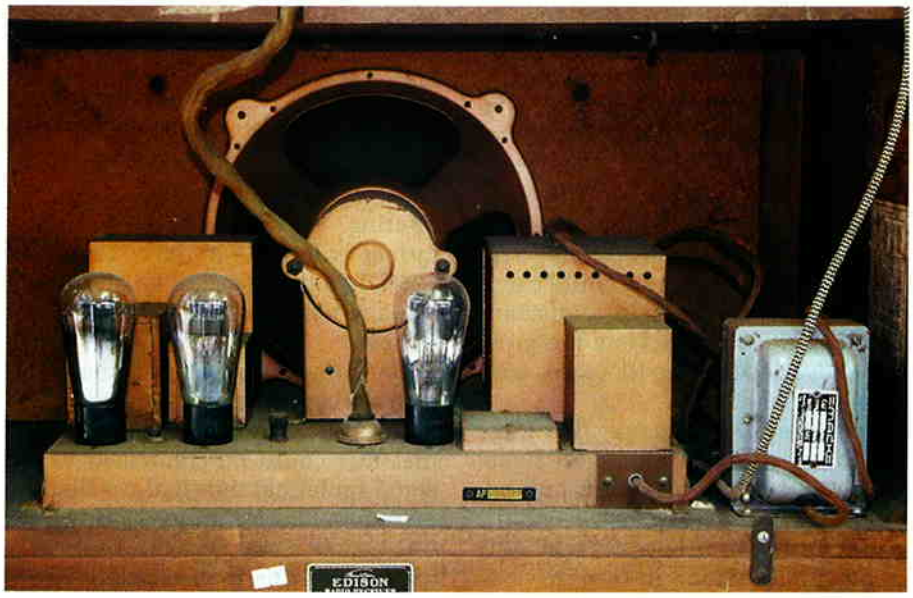
A rear view of the set reveals two large chassis mounted at different levels of the cabinet. The upper chassis contains the radio frequency (RF) amplifiers, the detector, automatic volume control circuit (AVC/AGC) and two stages of audio amplification. The lower and much heavier chassis houses the power supply and the audio output stages. Both chassis are in quite good condition, despite the set now being 75 years old.

This front view shows the Edison R6 console with the cabinet doors open.

R6 circuit details

At the time it was made, TRF (tuned radio frequency) receivers were the only sets being produced by manufacturers in large quantities, with superheterodyne receivers still largely in the experimental stages. Some TRF receivers were better than others and the Edison R6 with its nine valves shows its quality in terms of sensitivity, selectivity and audio performance.

The RF (radio frequency) section uses no less than three tuned circuits before the 224 (24) first RF amplifier stage. Following this stage is another tuned circuit and a second 224 RF amplifier. A third 224 RF amplifier is tuned in the grid circuit but the plate circuit has what appears to be a broadbanded circuit which feeds a 227 diode detector and AGC circuit.



A close-up view of the audio output/power supply chassis and the large electrodynamic loudspeaker. The added 240V/115V transformer looks out of place.

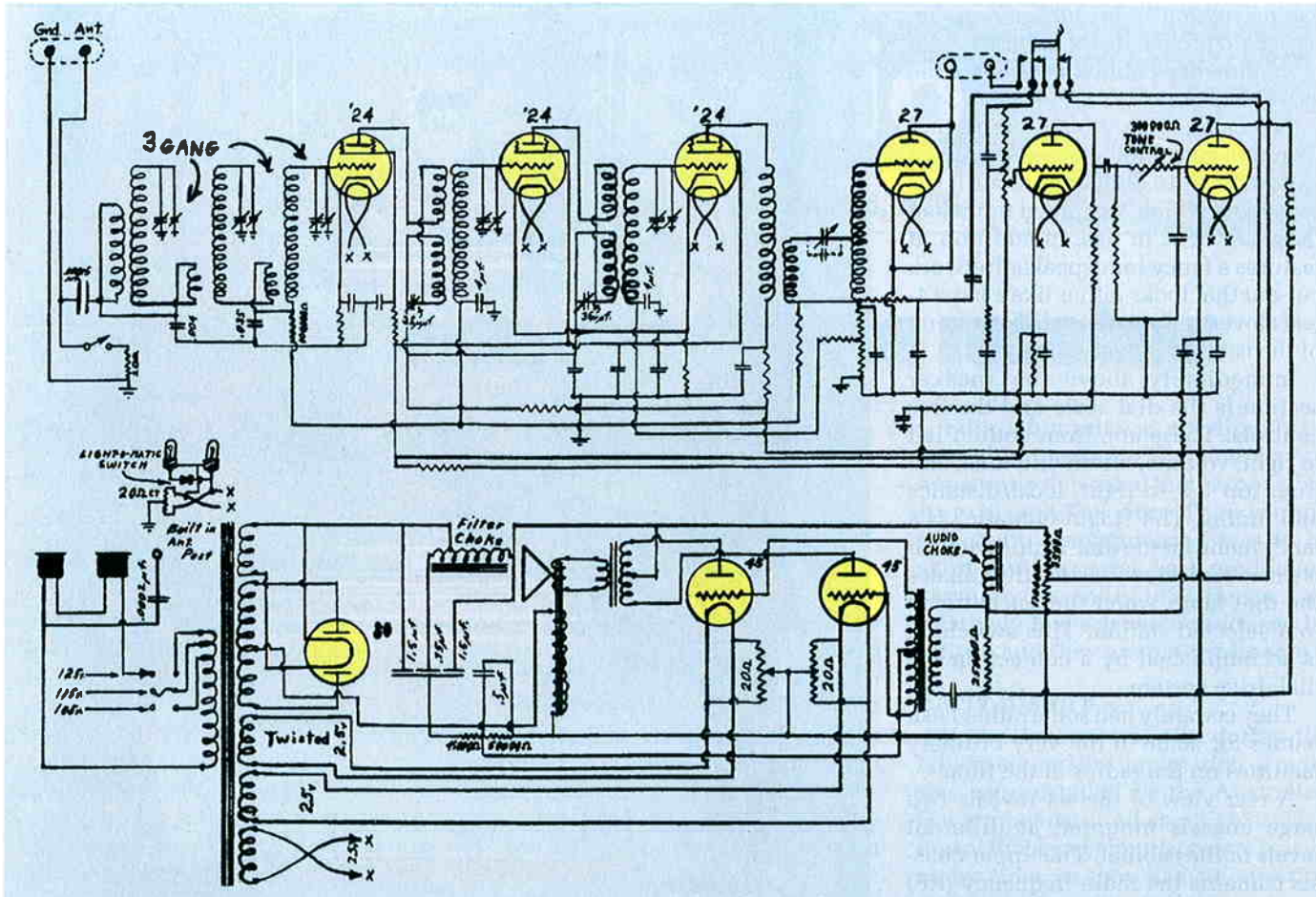


Fig.1: the Edison R6 is a 9-valve TRF receiver with three RF amplifier stages (224) and a diode detector based on a 227. Two more 227s act as audio stages, while the final audio stage consists of two 245 valves operating in push-pull. The 80 valve is the rectifier.

The 227 is actually a triode but in this circuit the plate is earthed (as a shield) and the grid acts as the diode plate. Using a diode as the detector can be considered an advanced feature in this set. Most other sets used either anode bend or grid detectors.

Another innovative feature was the use of AGC on the three RF valves. AGC was a rarity around 1930. Only partial AGC is applied to the third RF amplifier – the 224 is a relatively sharp cut-off valve and applying a lot of AGC bias to this stage could cause distortion. As it is, a local-distance switch is fitted to alleviate the problem of overloading the RF valves with strong signals.

Following the detector, two more 227 valves amplify the audio signal which is then fed to a push-pull audio transformer. This then feeds the grids of a pair of 245 valves operating in push-pull, which in turn drive an output transformer and an electrodynamic speaker.

To minimise hum in the audio, the two 245 valves each have a potentiometer across the filament transformer windings. These two pots have a ganged moving arm which goes to earth and is adjusted for minimum hum in the output.

Power supply

The power supply is conventional, with considerable attention paid to filtering. The primary of the transformer is tapped at 105V, 115V and 125V, hence the use of an additional stepdown transformer in this particular unit.

One interesting feature is the provision of a capacitor on the primary side of the transformer. The idea here was that this could be connected to the aerial (antenna) terminal, so that the mains could act as an aerial. However, this type of aerial system was usually quite noisy due to electrical interference on the mains. In addition, there was always a risk that the capacitor could break down and apply mains voltages to any external antenna, with possibly fatal results.

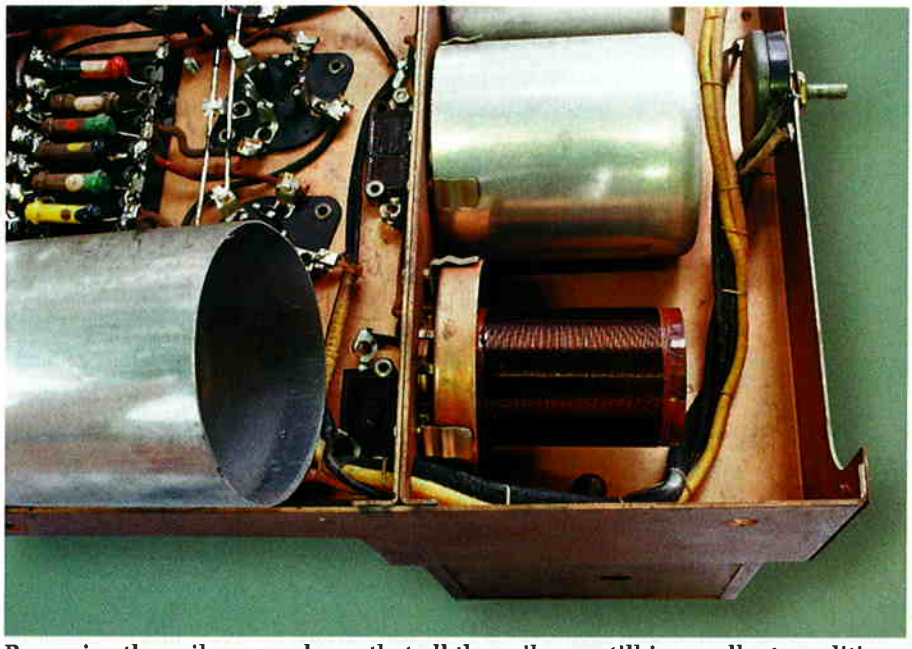
Leaving this capacitor disconnected and using a separate outside antenna was certainly a much better (and far safer) idea!

The HT secondary of the mains transformer is fed to an 80 rectifier valve (the 80 and 5Y3GT are electrically equivalent). The resulting DC is then applied to a tapped choke in the positive supply line, along with three filter capacitors. The field coil of the electrodynamic speaker acts as a filter in the negative line.

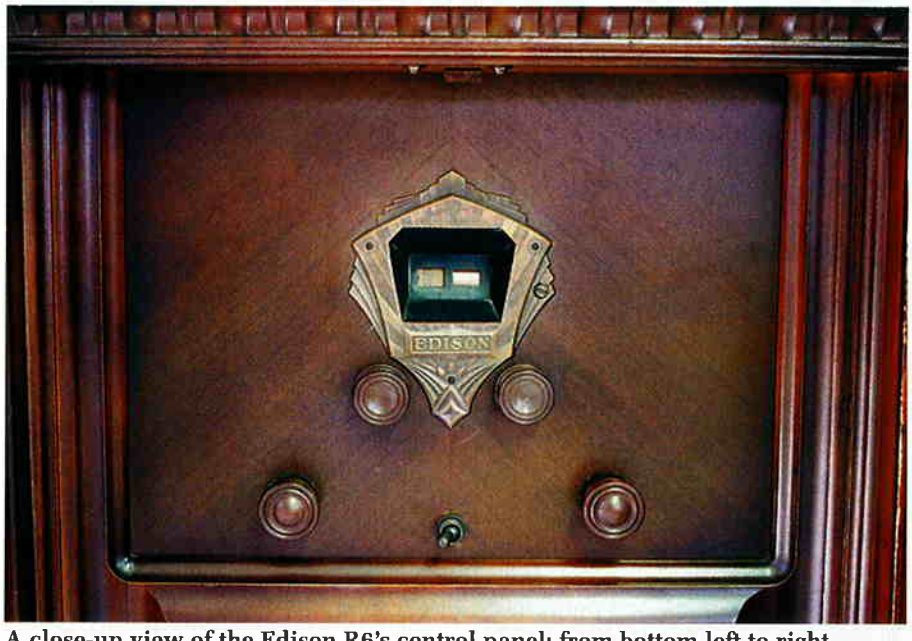
Finally, there are four filament windings on the secondary of the transformer, one five volt for the rectifier and three 2.5 volt ones for the rest of the receiver.

Alignment

The five RF circuits are tuned by two separate tuning capacitors (one 3-gang and one 2-gang), which are



Removing the coil covers shows that all the coils are still in excellent condition, despite now being more than 75 years old.



A close-up view of the Edison R6's control panel: from bottom left to right, volume, on/off and tone; and from top left to right, local/distance and tuning.

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mechanically coupled together. Although I have never had to align this receiver, I suspect that it would pay to carefully follow the correct procedure, otherwise the performance could be very mediocre.

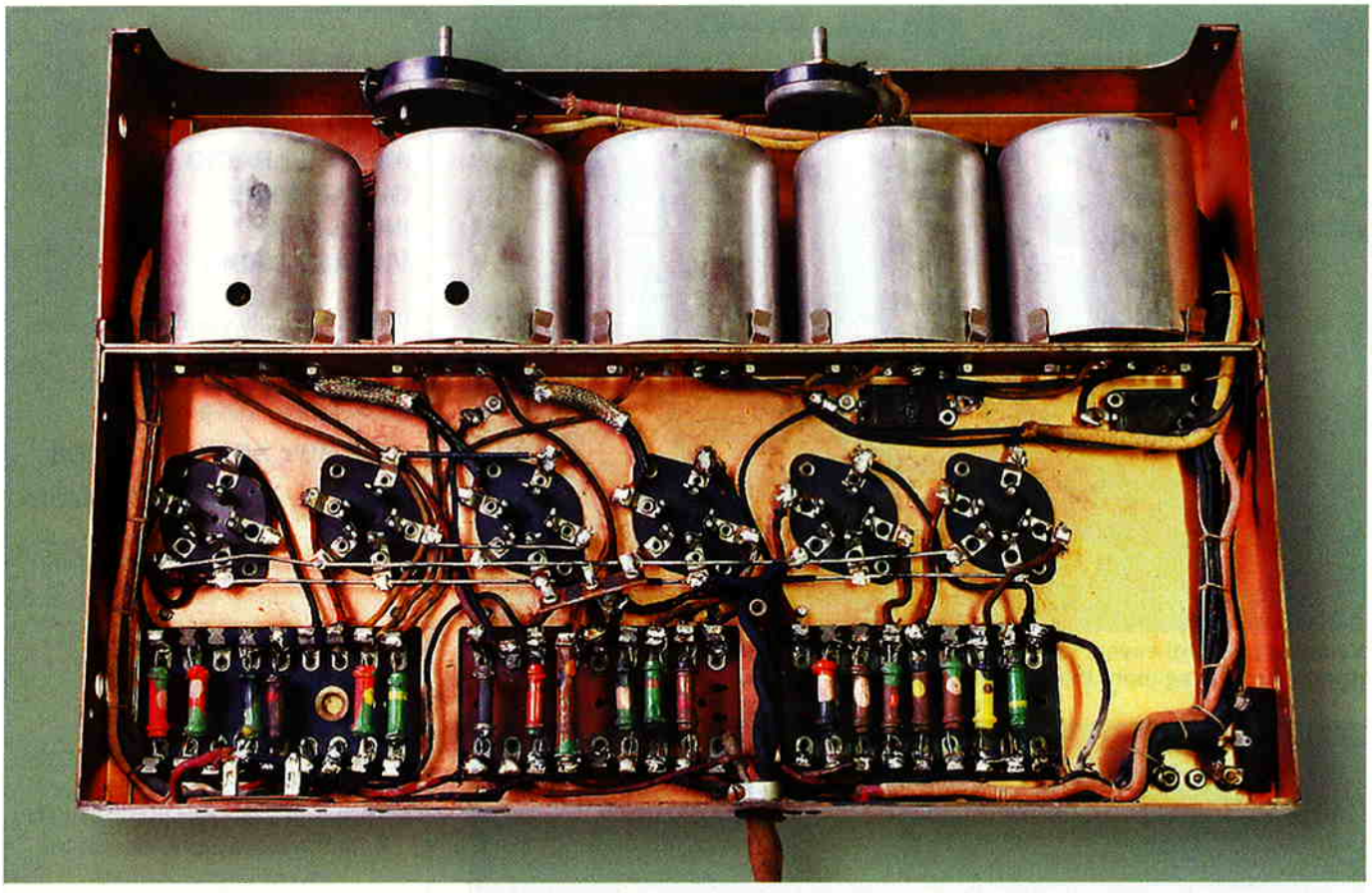
There are trimmers across the five tuning gangs and these would all be peaked at the high-frequency end of the tuning range. At first glance, there don't appear to be any adjustments at the low-frequency end of the dial. However, I wonder what the trimmer capacitors at the bottom ends of the RF primary windings on the two interstage transformers are for? It's quite possible that these alter the performance at the low-frequency end of the dial by changing the apparent inductance of the two tuned windings.

The first three tuned circuits do not have this feature. Personally, I would be tempted to note the positions of the trimmers and try adjustments at both ends of the dial to see what happened. If it all became pear-shaped, at least they could be set back to their original positions.

In this case, it was unnecessary to fiddle with the alignment, as the set is quite sensitive, has good selectivity and produces good quality audio.

Replacement parts

Most of the fixed capacitors in this set were replaced in the not too distant past. In this case, the old capacitors had been removed from their cases and the new ones substituted to keep the chassis looking original. Certainly, this job has been extremely well done, the step-down mains transformer be-



The parts on the underside of the RF chassis are very neatly laid out and easy to access. Note the row of coils at top.

Photo Gallery: Healing 527E 5-Valve Console

MANUFACTURED BY A. G. Healing, Melbourne, in 1946, the model 527E is an early post-war broadcast band console receiver. It featured a large rotating "barrel" type dial and a 30cm loudspeaker and combined good performance with attractive styling. A companion model, the 577E, was also produced and this included a shortwave band that tuned from 7.89MHz to 24MHz.

The valve line-up was as follows: 6J8-G frequency changer; 6U7-G IF amplifier; 6B6-G detector/audio amplifier/AVC rectifier; 6V6-G audio output; and 5Y3-G rectifier. Photo: Historical Radio Society of Australia, Inc.

ing the only item that's obviously a "ring-in".

Access under each of the chassis is quite good, with, all components neatly laid out and quite easy to get at. Access to the RF coils is also good, and the coil winding is still in excellent condition after all these years.

Summary

This is indeed a rare receiver and is probably the only one of its kind in Australia. It has a high-quality timber cabinet and when complete with the works, is a job for two people to lift. Both the chassis work and the wiring is also of good quality.

The set's performance is superb and is still quite useful in today's world, with stations quite close together in frequency. In summary, the Radio Division of Thomas A Edison Inc. produced a fine receiver. If their other models were of the same quality, they would have been excellent receivers – although rather expensive, I suspect.

Finally, my thanks to Brian Lackie for providing the information necessary for this article. SC

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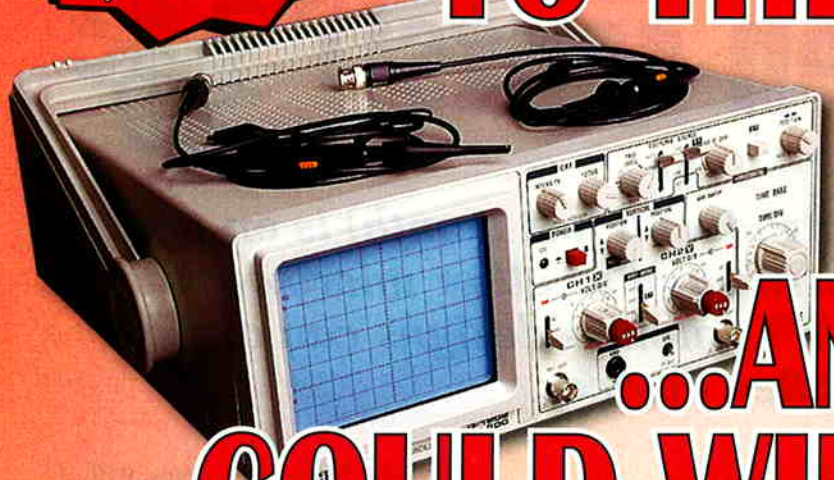

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Boost your ZigBEE range for a few bucks (or even cents!)

Since ZigBee (which we introduced last month) is on the same licence-free 2.4GHz band as other microwave services, many compact WiFi antenna designs can also be conveniently used with ZigBee devices.

by Stan Swan

Aside from range extension, especially valuable, given the tiny 1mW XBee transmitter power, such antennas may also help reduce unwanted RF noise picked up from the myriad of devices (WiFi, cordless and Bluetooth phones, microwave ovens, video senders etc) now flooding that same 2.4GHz spectrum slice.

Rev.Ed's XBee units come with a small factory-fitted wire radiator, although this looks shorter than the theoretical quarter-wave whip (31.5mm) of a 125mm 2.4GHz wave.

Outdoor range checks gave a good

You can make a variety of parabolic (and near parabolic) reflectors for ZigBee and even WiFi using simple (and cheap!) materials. More details are on Stan's website: www.orcon.net.nz

50-100m between bare units but were hugely influenced by the usual microwave line-of-sight (LOS) limitations.

Even shielding at 100m with your body will completely cut signals, as will vegetation in full leaf (it's actually the water in both which knocks the signal about).

Indoors, through timber and plaster walls, gave ~20m range. Remember that brick walls, especially external ones, absorb moisture so are always likely to be more of a problem.

Wireless data links likely to be subject to such obstacles may show more "punch" with cheaper (but slower) UHF 433MHz modules (see SILICON CHIP, December 2005).

Since each 6dB antenna gain doubles range, a simple 6dB antenna "point to point" at each end should yield 12dB (or four times) the bare range.

You can solder different antennas (such as a Biquad) to the XBee but rather than modifying the existing whip to improve coverage, it's perhaps easier to just position the entire XBee unit at the focal point of a simple concentrating reflector.

Outstanding LOS range extensions were shown by the 12-15dB gain parabolic "cookware" dish designs we first promoted for USB WiFi (see "WiFry Antennas", SILICON CHIP, September 2004 or **www.usbwifi.orcon.net.nz**).

XBee trials over water readily gave 3km links with these at both ends (see **www.picaxe.orcon.net.nz/zigscoop.jpg**) – quite amazing for 1mW and only modest receiver sensitivity. Such performance implies LOS ranges with swapped out XBee Pros (100mW transmitter and superior receiver) may only be limited by the curvature of the earth, as a DefCon WiFi shootout in dry-air-Nevada recently achieved ~200km LOS point-to-point with standard WiFi adaptors and (very) large dishes.

Naturally ZigBee setups won't have to stretch that far but may need a "helping hand". If parabolic maths leaves you numb, consider diverse DIY cardboard and foil template parabolas or corner reflectors that usefully enhance 2.4GHz signals , although accurate measuring and profiling may be needed. Again, see **www.usbwifi.orcon.net.nz/carwifi.jpg** and **www.usbwifi.orcon.net.nz/cnr.jpg**

The catenary curve of hanging chains approximates a parabola very closely (even Galileo in 1669 was fooled!) – see **www.usbwifi.orcon.net.nz/catcurve.jpg**.

But an even simpler DIY design, based around flexible plastic or metal sheet offcuts, has evolved – **www.usbwifi.orcon.net.nz/plaspara.jpg**. This exploits the little known fact that end-clamped rods and "bendy" sheets assume a roughly parabolic shape when flexed.

A few minutes with some springy plastic offcuts, string, glue and cooking foil can give you around 9dB gain – use the old "finger at the hot spot" trick to carefully find the focal point via reflected sunshine.

Even "bendy rulers" can be used, although a wider strip will give better performance. One at each end will give ~18dB system gain, enough for a 1km LOS XBee link.

Since offcut ends are cord secured, the concentration may be more cardioid ("heart shaped") than true parabolic but this is not too crucial – even the Arecibo Observatory's huge radio telescope reflecting dish is spherical. **SC**

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SILICON CHIP magazine aims to promote the education, development and application of electronic technology in all fields throughout Australia. As part of that aim, we are announcing the SILICON CHIP Excellence in Education Technology awards, with a prize pool of $10,000. Separate awards will be made to students of secondary schools throughout Australia and to students of universities and TAFE colleges throughout Australia.

The secondary school awards will have three categories:

(a) Best final year assignment of an individual student involving electronics technology
(b) An award to the school sponsoring the winning individual student
(c) Best school project involving electronics technology

The university and TAFE college awards will have three categories:

(a) Best project from a student as part completion of a degree, diploma or certificate in electronics or a related field (ie, mechatronics)
(b) Best research project from a post-graduate student working in an area of applied electronics
(c) An award to the university faculty or school sponsoring the best research project.

Entries and judging

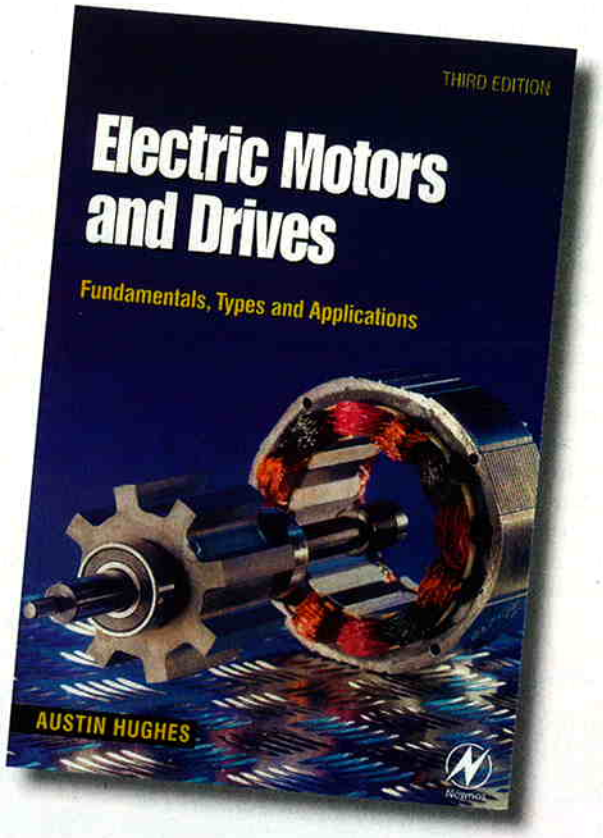
The awards will be judged by the editorial staff of SILICON CHIP, convened as a judges panel. The decisions of the judges will be final.

Entries for the 2006 awards are now open, with final submissions to be made by September 30th, 2006. All submissions will be confidential, until the winners are announced, in the December 2006 issue of SILICON CHIP.

Each award will take the form of a cash prize and a commemorative plaque. All enquiries about these awards should be directed to the editor via email to: **awards@siliconchip.com.au**

BOOK REVIEWS

Electric Motors and Drives; Fundamentals, Types and Applications, by Austin Hughes.
3rd edition published 2006 by Elsevier Ltd. Soft covers, 151 x 234mm, 410 pages. ISBN 0 7506 4718 3. $52.50 including GST.



This is the third edition of a book first published in 1990 and it has been substantially updated. It is a very useful reference book for anyone wanting a comprehensive understanding of motors and drives, without having to delve into extensive mathematics. It is particularly strong in its explanation of induction motors, the most common motor used in variable speed drives today.

Many readers may wonder why there are so many different types of electric motor and how they come to be used in particular applications. For example, why are permanent magnet motors universally used in battery-operated tools while universal (series) motors are the motor of choice in mains-power operated tools? Or why have induction motors with variable frequency inverter drives replaced series brush motors in all traction applications? Or what are the common features of induction motors and brushless DC motors?

To know the answers to these and many other motor-related questions you need to read and understand this book by Austin Hughes. I have not seen another book which covers this wide subject more comprehensively and in such an easy-to-read style. That is not to say, that it is easy bed-time reading – it is not. In fact, it took me quite a while to read and re-read some chapters as I undertook what was effectively a substantial revision of this most important area of engineering.

Nor is the book completely free of maths – formulas are often quoted and each chapter has worked examples and questions with worked solutions available on a website. Some knowledge of AC circuit theory is also required for best understanding of the chapters on drives and induction motors.

The book has 11 chapters and one appendix. Chapter 1 is on the basics of electric motors while chapter 2 is on the basics of electronic motor drives, covering choppers and thyristors (SCRs) and inverter switching devices such as Mosfets, IGBTs and GTOs. Chapter 3 is a comprehensive coverage of DC motors, including series, shunt, compound, universal and toy (permanent magnet).

I should note that battery-operated power tools and those used in cars (both normally permanent magnet types) do not get a specific mention. In fact, no auto electric motors (eg, series-wound starter motors or permanent magnet types) are covered although once you have read this book, you should have a good understanding of these types.

Chapter 4 covers DC motor drives, mostly to do with thyristor drives although chopper drives do get a mention, as do servo motors and position control and digital drives. But note that if you're looking for a good understanding of servos used in radio-controlled equipment, you will have to look elsewhere (starting with SILICON CHIP magazine).

Chapters 5 & 6 cover induction motors and their operating characteristics, with a thorough description of rotating magnetic fields, slip and torque, starting methods, speed control and so on. There are brief descriptions of single phase capacitor start motors, split phase motors and shaded pole motors (widely used in fans).

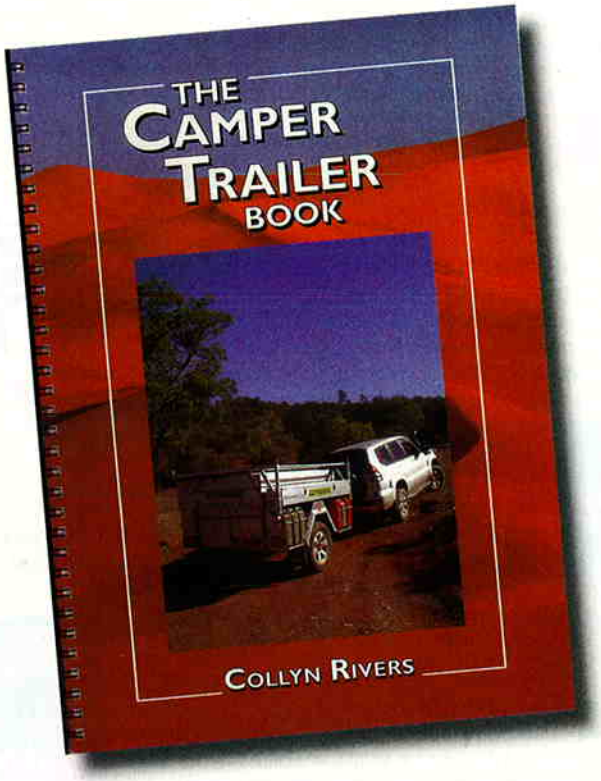
Chapter 7 is a very detailed description of the induction motor equivalent circuit which explains the similarity between an induction motor and a transformer.

Chapter 8 is on inverter-fed induction motor drives while chapter 9 is on stepper motors. Chapter 10 is on synchronous, brushless DC and switched reluctance drives, all of which are similar in principle to induction motors. Chapter 11 is on motor/drive selection. Finally, there is an appendix on closed-loop control.

To conclude, this is a very worthwhile book if you want a good reference on electric motors and drives. (L.D.S.)

This book is available from the SILICON CHIP Bookshop – see pages 104-105 of this issue for more information.

The Camper Trailer Book, by Collyn Rivers.
Self-published 2005. Soft covers, spiral bound, 210 x 296mm, 76 pages. ISBN 0 9578965 3 0. $42.50.



Why would you want a book on camper trailers? The answer is that there are thousands of such trailers on the roads around Australia and probably most are not properly set up for the long-term reliable service.

Collyn Rivers has written books on related topics such as Motorhome Electrics (reviewed in SILICON CHIP, February 2003) and is well-qualified to give a good over-view.

In only 76 pages and 24 chapters Collyn covers everything you could possibly want to know about camper trailers. There is very pertinent information about auxiliary batteries and charging, solar panels and regulators.

I thought it was all good information apart from the chapter on safety which talks about dealing with mosquitos, sand-flies, marine stingers, snakes and crocodiles. This includes a photo of a crocodile which is supposedly a freshwater type. To me, it looks identical to a saltwater crocodile – extremely dangerous.

In fact, I think his information about crocodiles should include the point that any sign of a crocodile is an immediate danger warning. If you see a small crocodile, there is probably a much larger one close by! Get out of there!

To purchase this book, contact the publisher at Caravan and Motorhome Books, PO Box 3634, Broome, WA 6725. Phone (08) 9192 5961; or via his website, www.caravanandmotorhomebooks.com SC

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Practical Variable Speed Drives and Power Electronics

by Malcolm Barnes. 1st Ed, Feb 2003.

An essential reference for engineers and anyone who wishes to design or use variable speed drives for induction motors. As reviewed in SILICON CHIP September 2003. 288 pages.

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By John Linsley Hood. First published 1995. Second edition 1999.

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by K.F. Ibrahim. Published 2003.

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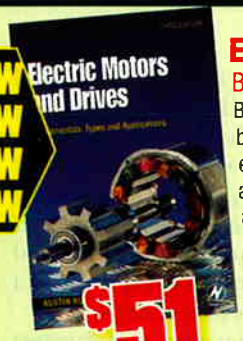

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Substituting drivers in the PA speaker

In the September 1996 issue of SILICON CHIP there was a project for a "high-quality loudspeaker for public address". The specified speakers (P17WG-00-08 and AD11600/T8) are hard to find now. Do you know of equivalent speakers that are readily available? (S. P., via email).

● Philips AD11600/T8 tweeters are now unavailable and the Vifa woofers are also hard to get. However, the designer of the project has since made an equivalent PA speaker using four C3086 165mm woofers and four C3003 25mm dome tweeters, from Altronics in Perth.

The design is similar to the original but with the following changes: First, the box is changed from 750 x 370 x 460mm to 800 x 440 x 440mm for a nominal internal capacity of 100 litres using 18mm MDF. The spacing between woofers and tweeters is 150mm; tweeter-to-tweeter spacing is 55mm; woofer-to-woofer spacing is 185mm. Port to tweeter spacing is 55mm.

The ports require a 65mm hole while the tweeters require an 80mm hole counter-bored to 104 x 4mm deep. The woofers require a 150mm hole counter-bored to 175 x 4mm deep. The two speaker ports are each 50mm in diameter and 200mm long.

The crossover arrangement is as per the 1986 design, with the two 3.2µF capacitors each used for the high-pass and the low-pass filters changed to 4.7µF. The inductor for the woofer crossover is changed from 0.82mH to 2.7mH. The inductor for the tweeter crossover is changed from 0.82mH to 0.56mH.

The 10µF/12Ω ohm shunt network across the woofers becomes 10µF and 8Ω. The attenuators for the tweeters change from 3.9Ω and 10Ω to 3.9Ω and 8.2Ω, respectively.

Tone generator needs decoupling

I recently built a tone generator using the circuit designed by Garry Cratt (VK2YBX) in SILICON CHIP, September 1989. While it works well, the audio output was a little low for IRLP use.

I added an amplifier stage using a 386 chip. This increased the audio output but it corrupted it so much that it was useless for the purpose.

Not long after that I obtained a tone generator that had been made for telephone banking (in the past). This unit was compact and worked well but again it is low on audio output. I added the 386 audio amplifier stage and got the same result as previously.

The question is: can you suggest an alternative chip/circuit that will not degrade the output tones? (H. M., via email).

● The reason why you are finding that the 386 corrupts the sound output is probably because you are using the same battery supply to run the tone generator and the amplifier. Is that right? If so, you need to "decouple" the supply to the generator circuit.

While we don't know the current drain of the generator circuit, we suggest you use a series 100Ω resistor in the generator positive rail and then connect a 470µF capacitor across the resulting generator supply.

LiPO battery discharge risk

I need some advice please. I have read the article on the electric model plane and the LiPO battery precautions in the February 2006 issue. It warns that the battery must not be discharged below 2.4V. This seems to be virtually impossible unless the battery is being used regularly or unless I find a charger that can maintain the battery in a charged state.

I have a similar problem with NiMH batteries in my camera. At first I had one set in the camera and another set in a microprocessor-controlled battery charger that I assumed would keep them on a float charge, like the charge/float LEDs indicated.

After several months when I got the second set out of the charger they were warm and so obviously had been on more that a float charge for all that time. The processor certainly wasn't looking after the batteries too well!

Preamp For A Ceramic Cartridge

Do you have a circuit or project details for a preamplifier that would suit a Dual 1010 record player which I think has a magnetic cartridge? I wish to copy some old family records onto CD. (D. N., Orange, NSW).

● It is unlikely that your Dual 1010 is fitted with a magnetic cartridge. It is more likely to have been fitted with a ceramic (piezoelectric) cartridge with a flip-over stylus and so it would require quite a different preamp to one designed for a magnetic cartridge. In brief, it should have a very high input impedance, a flat frequency response (no equalisation) and modest gain.

We have not produced a preamp specifically for a stereo ceramic cartridge although there was a mono circuit featured in the June 2002 issue (but no PC board). If you were keen, you could build a stereo hifi version of the valve preamplifier featured in the February 2004 issue. You should alter the grid resistor at pin of the 12AX7 valve to 4.7MΩ, to ensure good bass response.

This approach would be fairly expensive and for less money you could buy a complete turntable with an inbuilt preamplifier from Dick Smith Electronics or Tandy stores.

S-Video To Composite Video Conversion

My computer only has S-video in/out while my VCR only has composite video in/out and we want to be able to edit videos.

Do you know of a circuit or kit that can convert composite video to S-video and S-video to composite video? (J. M., via email).

● The Video Enhancer and Y/C Separator project described in the August 2004 issue of SILICON CHIP can be used to convert composite video signals into S-video form to feed into your PC.

Conversion of an S-video signal back into composite form is much simpler, especially if you only need to perform the conversion at a single composite video input (like the video input of your VCR). In this case, you can make up a simple adaptor by connecting a 4-pin mini DIN socket to a single RCA plug, with pins 3 & 4 of the mini DIN socket both connected to the inner lug of the RCA plug, and pins 1 and 2 of the mini DIN socket both connected to the outer (earth) lug of the RCA plug.

This "simplest possible" Y-C mixer introduces a small impedance mismatch and a small amount of signal loss but when placed right at the VCR's composite video input it usually gives satisfactory results.

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After that episode I charged the spare set and took them out of the charger but of course they didn't hold their charge for long; just like the batteries in my laptop that are always flat whenever I want to use it.

It seems that the only alternative is to have the camera batteries, laptop batteries, etc on charge all the time and so cook them into a shortened life span.

By chance I have been thinking about fitting an electric motor to a large glider that I rarely fly but after reading the article it seems that not only will the battery be flat when I want to use it but it will probably not even be able to be recharged and used. So what is the answer? (B. O., via email).

● There is no easy answer to your quandary. Even though some appliances may have low-battery protection, that will not stop LiPO batteries ultimately self-discharging below 2.4V if they are left uncharged for some time. It would seem that the only way to ensure that LiPO batteries (or any other batteries for that matter) do not ultimately become useless is to give them a top-up charge every few months or so. Either that or keep them permanently on a very low trickle charge, say only a few milliamps.

You are right though – batteries are a pest!

Fire sensor for a sprinkler system

I am currently trying to design a sprinkler system for my house to provide some protection in a bushfire and need some way of automatically triggering it when I am not there. I acknowledge that the system may not provide much help but I believe it is better to try something than just rely on the firefighters.

I am intending to have a water spray system to drench the building but the main issue is designing a sensor that could activate the system automatically.

A sensor that could sit on a mast and scan for an approaching fire front using some sort of element to detect fire flame signatures (have seen some American models which are very expensive) could perhaps be used. This could also be coupled with temperature and smoke sensors to provide a comprehensive image of the approaching fire. (E. P., via email).

● Apart from conventional smoke detectors we don't know anything about fire sensors. One possibility is to use a temperature sensor to sense the radiant heat of a fire. It could be tripped when the detected temperature rises above 70°C.

Remote volume control for amplifiers

I have purchased a remote volume control kit from Dick Smith Electronics in Christchurch, NZ. However, the potentiometer in the kit has a total of six pins and the existing potentiometer in my old Kenwood amplifier has a total of eight pins. Is it possible to get around this? (P. P., via email).

● It is probable that your Kenwood amplifier has a Loudness switch which operates via a tap connection on each channel's volume control potentiometer.

Clipping & Loudspeaker Protection For The Studio 350 Amplifier

I've built a Studio 350 power amplifier (SILICON CHIP, January & February 2004) and want to build a protection circuit which will stop the amplifier from going into clipping and also protect the speaker against output transistor failure. Have there been any suitable circuits published?

I found a Loudspeaker Protector project (SILICON CHIP, August 2000) but it seems to only be designed for DC faults. Do you think this circuit could be fairly easily modified to cope with both conditions? I wouldn't want the amplifier to completely shut off if it is going into clipping, just not drive any harder! (T. R. Auckland, NZ).

● The project you refer to is suitable for protecting your speakers from DC faults, such as output transistor failure. However, the power supply section of the design is not suitable for use running from the Studio 350's higher voltage supply rails. It would be best to modify the supply circuitry slightly so that it could be driven from an auxiliary 12V or 15V winding of the main power transformer.

We haven't published a clipping protection circuit. Although a good concept, its implementation is problematic. First, it is probably not desirable to simply disable the amplifier when clipping is detected, since "normal" music content at high volume levels will occasionally clip without causing any problems.

Instead, it would be better to have the clipping detector drive a limiting circuit ahead of the amplifier input, so that the signal is dynamically compressed. However, this idea has its own limitations, as much pop music has already been considerably compressed. Applying more compression at already high power levels may cause speaker or amplifier overload, as average power levels increase as compression increases.

We have published two limiter/compressor designs which would require considerable modifications for the job but they may prove of some interest anyway: (1) Versatile Electronic Guitar Limiter, October 1998; and (2) 1-Chip Guitar/Microphone Audio Compressor, March 1999.

You'll find an interesting clipping detector design on Elliott Sound Products website at **http://sound.westhost.com/project23.htm**

In that case, if you want the remote volume control, you will have to make do without the loudness feature. Hence, just wire up the six connections grouped together on the existing dual ganged potentiometer and ignore the tap connections – the loudness switch will no longer work.

Cheap LED torches not a good buy

I purchased a 6-LED torch that was made in China. The LEDs slowly deteriorated until one was blinking, one was weak and one was normal. The current limiting resistor used was surface-mount and marked 5R6 which I took to be 5.6Ω. I checked the resistor after removing all the white LEDs and it was 6.5Ω.

I then replaced the LEDs with 18,000mCd LEDs from Jaycar. They lit up like a bush fire. As I feel the resistor is too low, I replaced one of the three batteries with a copper bolt to reduce the voltage until I can find out how to determine the correct resistor value for six LEDs and 4.5V.

I know the correct formula for one LED but I have not seen how it is done with six LEDs. What do you suggest? (S. M., via email).

● If you have a look in the current Jaycar catalog, you will see that the 18,000mCd LED you used has a forward voltage of 3.3V (typical) and 3.6V (max). Typical operating current is 30mA but peak current is 100mA. With six LEDs in parallel, fresh cells giving 6V and a 5.6Ω limiting resistor, the total current drawn from the batteries would be around 430mA or about 70mA per LED. This is probably within the original LED's ratings but the trouble is that they won't share the current equally which is probably why they were progressively failing.

In a simple design such as this, you should have a separate resistor feeding each LED. Try a value of 56Ω. This will give an initial current of around 45mA with fresh cells but this will progressively drop as the cells discharge.

Leaving out a cell will give you less battery life, because you will start at 4.5V and have virtually no light output once it drops to below 3V or 1V per cell. If you have four cells and they discharge to a total of 3V, the end-point is 0.75V/cell which means longer battery life.

Adjusting PowerUP threshold

I saw the PowerUP project in the July 2003 issue. I want this unit to turn on my subwoofer when the TV is turned on using the remote. The thing is, the TV is always on standby, so there would always be a small amount of current going through the TV power supply. It would spike up when I turn it on with the remote and this is what I want to use to turn on the sub. (D. E., via email).

● The sensitivity threshold for the current monitoring is adjustable. If the standby current on the TV is still too high to be adjusted out, you can desensitise the circuit by using less turns on inductor L1 or by adjusting the gain of IC1a. A 500kΩ trimpot could be used instead of the 470kΩ feedback resistor on IC1a between pins 1 and 2. Adjust it so that the switching occurs when the TV is switched on from its standby position.

Reaction timer with millisecond display

I am trying to track down a kit to measure reaction time for secondary science students.

Ideally, a timer would start when a light is turned on (by a switch controlled by the teacher) and it would stop when another switch is pushed by the student. The time would then be displayed in milliseconds. We could then make up a rig linked to a foot-pedal, etc. (D. S., via email).

● We have published three reaction

timers which could be relevant to your enquiry: (1) Reaction Trainer (digital display) March 1993; (2) Test Your Reaction Timer With A PC (DOS program) February 1996; and (3) Reaction Timer (with display via a digital multimeter) June 2003.

Motor speed controller for motion control

I am writing in regards to the Full Range Motor Speed Controller in the November 1997 issue of SILICON CHIP. I am in the process of developing a PIC-based motion control system. The current mechanical loads in the system require an electric motor of about 0.75kW rating. The system operates at two speeds: full speed (500-600 RPM) and a crawl speed at about 5-10 RPM.

My initial thoughts were to use a 6-pole 3-phase motor (920 RPM), a 2:1 reduction belt drive and a suitable variable frequency controller. Unfortunately, these controllers are far too expensive and not really designed for interface to a microcontroller.

I then tried to locate a suitable stand-alone universal motor in the 1HP range but a lengthy search on the net found nothing (they are all built into power tools of some description).

I did however manage to find a stand-alone 1HP 180V brush permanent magnet DC motor (1750 RPM). Could this motor be used with the controller you published in 1997? It stands to reason that it should as it produces pulsed DC.

If this can be done, I intend to replace the 1kΩ resistor associated with VR1 (speed) with a 10kΩ trimmer to set the maximum voltage applied to the motor, as well as VR1 itself with two trimpots switched in and out of the circuit by suitable optocouplers, giving me two presetable speeds. Motor reversing will be via a high-current DPDT relay wired in the usual way.

Any feedback you can give on this subject would be greatly appreciated. (L. T., via email).

● The suggested speed controller should be fine although since the motor is only 180V, you could possibly get away with the simpler half-wave speed controller for universal motors, published in the October 2002. However, it may not have sufficiently good crawl speed control for your purpose.

Wants to build a LED clock

I am looking for a 12V LED clock with mid-size LED displays (around 20mm height). Can you help me? (P. M., via email).

● These days, most people would not bother building a digital clock since they are so cheap to buy but have a look at the 4-digit LED clock in the April 1993 issue. It uses 4000-series CMOS logic ICs and common cathode 7-segment LED displays. **SC**

How To Detect A Radar Detector

In "Mailbag" for February 2006, you published a letter from Brad Sheargold who asked a number of questions, many of which you answered but one in particular I noticed you left unanswered. Brad asked: "police claim to be able to detect radar detectors (if these are only receivers I don't know how they can do this – can you explain?)".

I have been told that police are able to detect radar detectors due to some of the superheterodyne oscillations of the receiver actually radiating from it. Is this correct?

I have also heard that some electronics "gurus" have been able to modify their radar detectors to shift the superheterodyne oscillations outside the range of frequencies being monitored by the "radar detector detectors" thus rendering them undetectable. Is this feasible? If so, how would it be done? (T. L., via email).

● You are quite right. The local oscillator in the car's radar detector itself radiates and can be picked up by police receivers. It may be feasible to shift the local oscillator but it would not be simple and may still be detectable by the police.

Notes & Errata

VoIP Analog Phone Adaptor, September 2005: the line (speaker) output connector on most PC sound cards is colour-coded green, not blue as stated in the article. Also, the adaptor will not work with professional audio sound cards that lack an internal microphone preamp.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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Advertising Index

555 Electronics 103
Altronics 84-87
Aspen Amplifiers 111
Alternative Technology Assoc 43
Av-Comm 111
BitScope Designs 39
Dick Smith Electronics 18-23
Digital Graphics 111
Eco Watch 111
Elexol 83
Evatco 97
FreeNet Antennas 110
Furzy Electronics 112
Futurlec 107
Grantronics 110
Harbuch Electronics 93
Instant PCBs 112
Jaycar IFC,53-60,93,112
JED Microprocessors 5,93
Laceys TV 111
LD Antennas 111
Microbric ..... IBC
Microgram Computers 3
MicroZed Computers 41
MiMar Resources 111
Oatley Electronics 71
Ocean Controls 110
Quest Electronics 93,111,112
Radio Parts ..... OBC
RCS Radio 111
RF Modules 93
Silicon Chip Binders 33,35
Silicon Chip Bookshop 104-105
SC Perform. Elect. For Cars 38
Silicon Chip Subscriptions 61,99
Silicon Chip Technology Awards 101
Silvertone Electronics 111
Siomar Batteries 37
Speakerbits 111
Taig Machinery 111
Telelink 37,93

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